PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	D5, C8, D3
2.	2	U	7	2	E7, 10, 2
3.	3	U	7	3	H3
4.	4	U	7	4	J2, B2
5.	5	U	7	5	L6, 5
6.	6	U	9	6	M11, N2
7.	7	U	7	7	P5, P3
8	8	H	5	1	A10, E7
9.	9	H	4	1	C8, D4

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:

Q = Question Number
CO = Curriculum Organizer
PLO = Prescribed Learning Outcome
B = Score Box Number
K = Keyed Response
C = Cognitive Level
S = Score

Physics 12

June 2000 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	**Sub-Organizers**
1.	Vector Kinematics in Two Dimensions *and*	A, B
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power *and*	E
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion *and*	I
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	CO	PLO	Q	K	C	CO	PLO
1.	A	K	1	A1	16.	D	K	4	J3, 2
2.	C	U	1	B2	17.	D	U	4	J1, 2
3.	D	U	1	B5	18.	D	K	4	K4
4.	C	K	1	C1, 3	19.	D	U	5	L8
5.	D	U	1	D4, C2	20.	C	H	5	L6
6.	A	K	2	E4, E5	21.	A	K	5	M9
7.	B	U	1	E7	22.	B	U	6	M11
8.	C	U	2	E3, 5	23.	C	H	6	M5, 6
9.	C	U	2	E10	24.	B	K	6	P2
10.	A	K	3	F5, 6, E8	25.	C	U	7	O3, 1, 2
11.	B	U	3	H3, 2	26.	C	U	7	O4
12.	D	K	3	H4	27.	B	U	7	O6
13.	C	U	4	H5, 11	28.	D	U	7	P4
14.	B	U	4	I5, D4	29.	A	U	7	P9
15.	B	U	4	I4	30.	A	H	7	O5, P1, M5, C4

Multiple Choice = 60 marks

164

Physics 12
August 2000 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions	A, B
	and	
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power	E
	and	
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion	I
	and	
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	CO	PLO	Q	K	C	CO	PLO
1.	D	K	1	C2, 3	16.	D	U	4	J2
2.	B	U	1	C4, 3	17.	A	U	4	J6
3.	C	U	1	C4	18.	D	K	4	K7
4.	A	U	1	C8, D5	19.	B	U	5	K5
5.	A	U	1	D6	20.	B	H	5	L6
6.	A	K	2	E8	21.	A	K	5	M4, A10
7.	B	U	2	E10	22.	B	U	6	M11, 6
8.	C	U	2	E7	23.	C	H	6	M6, 7
9.	B	H	2	E7, B8	24.	C	K	6	O2
10.	D	K	3	H4	25.	B	U	7	O4
11.	B	U	3	H3	26.	A	U	7	O6
12.	A	K	3	I1, 2	27.	B	U	7	O7
13.	C	U	4	I4	28.	B	U	7	P5, 3
14.	D	U	4	I4	29.	B	U	7	P8, 9
15.	D	K	4	J4	30.	A	U	7	P11

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	C8, C3, E8
2.	2	U	7	2	G3
3.	3	U	7	3	H11
4.	4	U	9	4	J9, J8
5.	5	U	7	5	L6
6.	6	U	7	6	M5, 7
7.	7	U	7	7	P11
8	8	H	5	1	A10, B2
9.	9	H	4	7	I5

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:
Q = Question Number B = Score Box Number C = Cognitive Level
CO = Curriculum Organizer K = Keyed Response S = Score
PLO = Prescribed Learning Outcome

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	A9
2.	2	U	9	2	F4, 7
3.	3	U	7	3	H11
4.	4	U	7	4	J7
5.	5	U	7	5	L6
6.	6	U	7	6	M5, 6, 7, N2
7.	7	U	7	7	O8, P3
8	8	H	5	1, 2	A10, E10
9.	9	H	4	3	H2, H3

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:

Q = Question Number	B = Score Box Number	C = Cognitive Level
CO = Curriculum Organizer	K = Keyed Response	S = Score
PLO = Prescribed Learning Outcome		

Physics 12

January 2001 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions	A, B
	and	
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power	E
	and	
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion	I
	and	
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO
1.	C	K	2	1	A7
2.	C	U	2	1	B2
3.	A	U	2	1	B4, 5
4.	D	K	2	1	D4
5.	B	U	2	1	C4, 7
6.	D	U	2	1	D6; C4
7.	C	U	2	2	E10
8.	C	K	2	2	F2; E4; A1
9.	C	U	2	2	F6, 7; E7
10.	C	U	2	2	G3
11.	C	H	2	2	F1; A10
12.	B	K	2	3	H7
13.	B	U	2	3	H5
14.	DELETED				
15.	A	K	2	4	I3

Q	K	C	S	CO	PLO
16.	D	U	2	4	I4
17.	B	U	2	4	I4; D5
18.	D	K	2	4	J5, 6
19.	C	H	2	4	I4; D5
20.	B	K	2	5	L1
21.	A	U	2	5	K3
22.	A	U	2	5	K8
23.	D	U	2	6	M6
24.	D	U	2	6	M5; N2
25.	B	K	2	7	O2
26.	D	U	2	7	O4
27.	B	U	2	7	O5
28.	A	U	2	7	P4, 6; O3
29.	B	U	2	7	P9
30.	A	U	2	7	P2, 3, 5

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	C4, 8; D4
2.	2	U	7	2	E7, 8; F7
3.	3	U	7	3	H3; C8
4.	4	U	7	4	J3; D5
5.	5	U	7	5	K5
6.	6	U	7	6	N2; M6, 5
7.	7	H	9	7	O4, 6; I1, 4
8	8	H	5	1	A10; F4
9.	9	H	4	4	J8

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = 120 marks

LEGEND:

Q = Question Number	B = Score Box Number	C = Cognitive Level
CO = Curriculum Organizer	K = Keyed Response	S = Score
PLO = Prescribed Learning Outcome		

Physics 12

June 2001 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	**Sub-Organizers**
1.	Vector Kinematics in Two Dimensions *and*	A, B
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power *and*	E
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion *and*	I
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	B	K	2	1	A1	16.	C	H	2	4	I4; D5
2.	B	U	2	1	B2	17.	D	K	2	4	J5
3.	A	U	2	1	B8	18.	A	U	2	4	J7
4.	D	K	2	1	C3	19.	D	K	2	5	K8; D4
5.	B	U	2	1	D6; C4	20.	D	U	2	5	L3; K4
6.	B	K	2	2	E1, 4	21.	C	K	2	6	M1
7.	D	U	2	2	E10	22.	B	U	2	6	M11
8.	C	U	2	2	E2, 5	23.	B	H	2	6	N2; M7
9.	D	U	2	2	E10; N2	24.	C	K	2	7	O9
10.	D	U	2	2	F4	25.	D	U	2	7	O4
11.	D	K	2	3	H4	26.	A	U	2	7	O1, 3
12.	C	U	2	3	H3; D5	27.	D	U	2	7	P5
13.	C	U	2	3	H11	28.	B	U	2	7	P1; O4
14.	A	U	2	4	I4; D5; C8	29.	D	U	2	7	P9
15.	B	U	2	4	I3; A10	30.	B	H	2	7	P1, 6; M5

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	H	9	1	C4, 3; D3, 5
2.	2	U	7	2	G3
3.	3	U	7	3	H11
4.	4	U	7	4	J6, 9, 10
5.	5	U	7	5	L8
6.	6	U	7	6	M11, 6, 5; N2
7.	7	U	7	7	O6, 8
8	8	H	5	1	O5; A10
9.	9	H	4	7	L8; K6; L1

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = 120 marks

LEGEND:
Q = Question Number
CO = Curriculum Organizer
PLO = Prescribed Learning Outcome
B = Score Box Number
K = Keyed Response
C = Cognitive Level
S = Score

Physics 12

August 2001 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions	A, B
	and	
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power	E
	and	
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion	I
	and	
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	B	K	2	1	C1	16.	A	K	2	4	J3
2.	C	U	2	1	C7	17.	B	U	2	4	J9, 8
3.	A	U	2	1	D3	18.	A	U	2	4	J10
4.	C	U	2	1	C8	19.	D	K	2	5	K6, 7
5.	D	U	2	1	D5; C4	20.	D	U	2	5	K8, 6
6.	B	K	2	2	E10	21.	B	U	2	5	L5
7.	B	U	2	2	E8	22.	D	K	2	6	M9
8.	C	U	2	2	E3	23.	B	U	2	6	M5, 6
9.	D	H	2	2	E8, 5	24.	B	K	2	7	P13
10.	A	K	2	3	H10	25.	B	U	2	7	O4
11.	C	U	2	3	H3	26.	C	U	2	7	O7, 3
12.	A	U	2	3	H11	27.	A	U	2	7	P1, 5; O4
13.	B	K	2	4	I1	28.	B	U	2	7	P9
14.	D	U	2	4	I4, 3	29.	B	U	2	7	P11
15.	B	H	2	4	I4; D5	30.	C	H	2	7	O4, O5; D3

Multiple Choice = 60 marks

16

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	B8, 7
2.	2	H	9	2	F4; E7
3.	3	U	7	3	H11; D4
4.	4	U	7	4	J7
5.	5	U	7	5	L6; K8; C4
6.	6	U	7	6	M2, 5; N2, 3
7.	7	U	7	7	O6, 8
8	8	H	5	1	A10; E3
9.	9	H	4	6	M11

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = 120 marks

LEGEND:
Q = Question Number   B = Score Box Number   C = Cognitive Level
CO = Curriculum Organizer   K = Keyed Response   S = Score
PLO = Prescribed Learning Outcome

Physics 12
January 2002 Provincial Examination
ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions *and*	A, B
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power *and*	E
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion *and*	I
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	A	K	2	1	A1	16.	A	U	2	4	J2; C6
2.	C	U	2	1	A7, 9	17.	B	H	2	4	J9
3.	D	U	2	1	B8	18.	C	K	2	5	K6
4.	D	K	2	1	D4	19.	C	U	2	5	K5
5.	C	U	2	1	C8; D6	20.	C	K	2	6	M3
6.	C	U	2	2	E3	21.	A	U	2	6	M2; N2
7.	B	K	2	2	F1	22.	C	U	2	6	M5, 7, 6
8.	D	U	2	2	F4	23.	A	K	2	7	O1
9.	B	U	2	3	H3	24.	B	U	2	7	O3, 4
10.	D	U	2	3	H11, 5	25.	D	U	2	7	O5; C4
11.	B	H	2	3	H11, 5	26.	B	U	2	7	O8
12.	C	K	2	4	I3, 1	27.	B	U	2	7	P1; O6
13.	B	U	2	4	I5	28.	A	U	2	7	P5, 6
14.	B	U	2	4	I4	29.	B	U	2	7	P8, 9; E10
15.	C	K	2	4	J4	30.	A	H	2	7	P5, 7, 2

Multiple Choice = 60 marks

16

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	D4; C8
2.	2	H	9	2	E7, 8; B2
3.	3	U	7	3	H11, 5
4.	4	U	7	4	J7, 9, 10
5.	5	U	7	5	L2; E10
6.	6	U	7	6	M5, 6, 7
7.	7	U	7	7	O6; C4
8	8	H	5	1	A10; P9
9.	9	H	4	2	F4; A10

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:
Q = Question Number — B = Score Box Number — C = Cognitive Level
CO = Curriculum Organizer — K = Keyed Response — S = Score
PLO = Prescribed Learning Outcome

Physics 12
June 2002 Provincial Examination
ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	Sub-Organizers
1. Vector Kinematics in Two Dimensions *and*	A, B
Dynamics *and* Vector Dynamics	C, D
2. Work, Energy and Power *and*	E
Momentum	F, G
3. Equilibrium	H
4. Circular Motion *and*	I
Gravitation	J
5. Electrostatics	K, L
6. Electric Circuits	M, N
7. Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO
1.	A	K	2	1	D3, 5
2.	A	U	2	1	C4, 3
3.	A	U	2	1	C8, 7
4.	C	U	2	1	D6; C4
5.	D	U	2	1	C4, 8
6.	B	U	2	2	E10
7.	A	K	2	2	F6
8.	D	U	2	2	F4; A10
9.	A	U	2	2	G3
10.	A	K	2	3	H8, 11
11.	B	U	2	3	H3, 2
12.	A	U	2	3	H5
13.	C	K	2	4	I1, 3
14.	D	K	2	4	J3
15.	C	U	2	4	J1, 2
16.	C	U	2	4	J2
17.	C	U	2	4	I4; J2
18.	C	H	2	4	J6, 7; E7
19.	B	K	2	5	L1
20.	B	U	2	5	K8; C4
21.	B	H	2	5	K8; D3, 5; C7
22.	D	K	2	6	M9
23.	B	U	2	6	M7, 11, 6
24.	D	H	2	6	M5, 6, 11; N2
25.	A	K	2	7	O3, 8
26.	C	U	2	7	O5, 4
27.	A	U	2	7	O6
28.	B	U	2	7	P5, 3
29.	D	U	2	7	P8, 9, 10
30.	D	U	2	7	P4, 8, 11

Multiple Choice = 60 marks

Ⅎ

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	B8, 7
2.	2	U	7	2	E7
3.	3	U	7	3	H11, 5
4.	4	H	9	4	I4
5.	5	U/A	7	5	L2, 8
6.	6	U	7	6	M11; N2
7.	7	U	7	7	P3, 5
8	8	H	5	1	A10; F4
9.	9	U	4	7	O4; P6

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = 120 marks

LEGEND:
Q = Question Number
CO = Curriculum Organizer
PLO = Prescribed Learning Outcome
B = Score Box Number
K = Keyed Response
C = Cognitive Level
S = Score

Physics 12

August 2002 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	**Sub-Organizers**
1. Vector Kinematics in Two Dimensions *and*	A, B
Dynamics *and* Vector Dynamics	C, D
2. Work, Energy and Power *and*	E
Momentum	F, G
3. Equilibrium	H
4. Circular Motion *and*	I
Gravitation	J
5. Electrostatics	K, L
6. Electric Circuits	M, N
7. Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO
1.	D	K	2	1	B6
2.	B	U	2	1	B8
3.	D	U	2	1	B2; D6
4.	C	K	2	1	C6
5.	B	U	2	1	C8; D6
6.	A	K	2	1	E5
7.	C	U	2	2	E7
8.	C	U	2	2	F3
9.	A	K	2	3	H4
10.	B	U	2	3	H3
11.	B	U	2	3	H5, 11
12.	B	K	2	4	I1; C3
13.	A	U	2	4	I5
14.	C	U	2	4	I4; C8
15.	D	U	2	4	I4
16.	B	U	2	4	J9, 10
17.	B	U	2	4	J6, 7
18.	C	K	2	5	L7
19.	D	U	2	4	K2
20.	C	H	2	5	L8; K5
21.	A	K	2	6	M6
22.	C	U	2	6	N2; M2
23.	B	H	2	6	M11, 7
24.	C	K	2	7	P1
25.	D	U	2	7	O3
26.	A	U	2	7	O6; F1
27.	A	U	2	7	O8; A10
28.	B	U	2	7	P9
29.	A	U	2	7	P11, 12
30.	D	H	2	7	P5; B2

Multiple Choice = 60 marks

Physics 12

January 2003 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	**Sub-Organizers**
1.	Vector Kinematics in Two Dimensions *and* Dynamics *and* Vector Dynamics	A, B; C, D
2.	Work, Energy and Power *and* Momentum	E; F, G
3.	Equilibrium	H
4.	Circular Motion *and* Gravitation	I; J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	A	K	2	1	C1	16.	D	U	2	4	J9
2.	B	U	2	1	C4, 7	17.	A	U	2	4	J7
3.	D	U	2	1	D1, 3	18.	D	K	2	5	K6
4.	A	U	2	1	C8, C4	19.	A	U	2	5	K5
5.	C	U	2	1	D6; B2	20.	C	H	2	5	L6
6.	C	K	2	2	E1	21.	A	K	2	6	M4, 7
7.	B	U	2	2	E7; A10	22.	B	U	2	6	N2; M7
8.	B	U	2	2	E2, 7	23.	B	H	2	6	M5
9.	A	H	2	2	E7, 8, 2	24.	C	K	2	7	P2
10.	D	K	2	3	H4	25.	A	U	2	7	O4, 5
11.	B	U	2	3	H1	26.	C	U	2	7	O8
12.	D	K	2	4	I5, 1; B3	27.	D	U	2	7	O6
13.	D	U	2	4	I4	28.	C	U	2	7	P5
14.	C	U	2	4	I4	29.	B	U	2	7	P9
15.	A	K	2	4	J8	30.	A	U	2	7	P11

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	D4; C4, 8
2.	2	U	7	2	G3
3.	3	U	7	3	H5, 11
4.	4	U	7	4	J9
5.	5	H	9	5	K8; C4; L6
6.	6	U	7	6	M7, 5; N2
7.	7	U	7	7	P3, 5
8	8	H	5	1	A10; B2
9.	9	H	4	2	E8, 10; C8; D6

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = **120 marks**

LEGEND:

Q = Question Number	B = Score Box Number	C = Cognitive Level
CO = Curriculum Organizer	K = Keyed Response	S = Score
PLO = Prescribed Learning Outcome		

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	B2, 8
2.	2	H	9	2	F4, 7, 5
3.	3	U	7	3	H8, 10, 11
4.	4	U	7	4	J3, 7
5.	5	U	7	5	L4
6.	6	U	7	6	M11, 10
7.	7	U	7	7	O5; P1
8	8	H	5	1	A10; B2
9.	9	H	4	3	H2, 3

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:

Q = Question Number	B = Score Box Number	C = Cognitive Level
CO = Curriculum Organizer	K = Keyed Response	S = Score
PLO = Prescribed Learning Outcome		

Physics 12

June 2003 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions *and* Dynamics *and* Vector Dynamics	A, B; C, D
2.	Work, Energy and Power *and* Momentum	E; F, G
3.	Equilibrium	H
4.	Circular Motion *and* Gravitation	I; J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO
1.	B	K	2	1	B5
2.	B	U	2	1	B8
3.	C	U	2	1	A9
4.	C	K	2	1	C1
5.	B	U	2	1	C4; D3
6.	D	K	2	2	E9
7.	D	U	2	2	E10
8.	C	U	2	2	E2; D1
9.	C	U	2	2	E2, 7
10.	C	U	2	2	G1, 3
11.	A	K	2	3	H4
12.	C	U	2	3	H2, 3
13.	A	U	2	3	H11
14.	B	U	2	4	I1, 3; A1
15.	C	U	2	4	I4
16.	D	K	2	4	J3
17.	C	U	2	4	J2
18.	D	K	2	5	K6
19.	A	U	2	5	L8
20.	C	H	2	5	L4, 6
21.	A	K	2	6	M4; A10
22.	D	U	2	6	N2; M7
23.	D	H	2	6	M5, 7
24.	B	K	2	7	O3
25.	B	U	2	7	O2
26.	A	U	2	7	O4
27.	A	U	2	7	O6
28.	C	U	2	7	P1; O4
29.	B	U	2	7	P5
30.	B	H	2	7	P5; M2

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	D6
2.	2	U	7	2	G3; E7
3.	3	U	7	3	H3
4.	4	H	9	4	J2, 8
5.	5	U	7	5	K8; L3
6.	6	U	7	6	M11; N2
7.	7	U	7	7	P5
8	8	H	5	1, 2	A10; E3
9.	9	H	4	4	I5

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:

Q = Question Number	B = Score Box Number	C = Cognitive Level
CO = Curriculum Organizer	K = Keyed Response	S = Score
PLO = Prescribed Learning Outcome		

Physics 12

August 2003 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	**Sub-Organizers**
1. Vector Kinematics in Two Dimensions *and*	A, B
Dynamics *and* Vector Dynamics	C, D
2. Work, Energy and Power *and*	E
Momentum	F, G
3. Equilibrium	H
4. Circular Motion *and*	I
Gravitation	J
5. Electrostatics	K, L
6. Electric Circuits	M, N
7. Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	A	K	2	1	A8	16.	A	K	2	4	J1; C2
2.	A	U	2	1	A7	17.	B	U	2	4	J2
3.	B	U	2	1	B8	18.	C	H	2	4	J9, 8
4.	D	K	2	1	C8	19.	C	K	2	5	L1; A10
5.	A	U	2	2	E7; C3	20.	C	U	2	5	L6
6.	D	K	2	2	F2	21.	D	U	2	5	L7
7.	B	U	2	2	F4	22.	A	U	2	6	M7; N2
8.	B	U	2	2	F7	23.	D	U	2	6	M11
9.	B	U	2	2	G3	24.	B	K	2	7	O3
10.	B	K	2	3	H1	25.	D	U	2	7	O4
11.	C	U	2	3	H8	26.	B	U	2	7	O6
12.	B	H	2	3	H11	27.	D	U	2	7	P11, 13
13.	D	K	2	4	I1	28.	B	U	2	7	O5
14.	B	U	2	4	I4	29.	C	U	2	7	O3; P6
15.	C	U	2	4	I4	30.	A	H	2	7	O6

Multiple Choice = 60 marks

174

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	C8; D3, 6
2.	2	U	7	2	E10
3.	3	U	7	3	H3
4.	4	U	7	4, 2	J8; I4
5.	5	U	7	5	L4
6.	6	H	9	6	M11, 7
7.	7	U	7	7, 6	P5; M5
8	8	H	5	1, 7	A10; P1
9.	9	H	4	1	C8; D1

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = 120 marks

LEGEND:
Q = Question Number — B = Score Box Number — C = Cognitive Level
CO = Curriculum Organizer — K = Keyed Response — S = Score
PLO = Prescribed Learning Outcome

Physics 12
January 2004 Provincial Examination
ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions *and*	A, B
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power *and*	E
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion *and*	I
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO
1.	D	K	2	1	A1
2.	B	U	2	1	A2
3.	B	U	2	1	B8
4.	A	K	2	1	C3
5.	B	U	2	2	C3, 7; D5
6.	A	U	2	2	D5; C4
7.	A	U	2	2	E2, 7
8.	C	K	2	2	F4, 5; C3
9.	D	U	2	2	F4; A10
10.	B	U	2	3	G3
11.	C	H	2	3	F4, 7; A8
12.	A	K	2	3	H7
13.	C	U	2	4	H5
14.	B	H	2	4	H5
15.	A	K	2	4	I3
16.	B	U	2	4	I5
17.	B	U	2	4	I4
18.	A	H	2	4	I4; C8
19.	C	K	2	5	J1
20.	A	K	2	5	K4, 6
21.	C	U	2	5	K5
22.	D	U	2	6	L4
23.	C	U	2	6	M7
24.	D	U	2	7	N2; M6
25.	D	K	2	7	O2
26.	B	U	2	7	O3
27.	A	U	2	7	O4; M5
28.	B	U	2	7	P1
29.	D	U	2	7	P2
30.	A	U	2	7	P11; N2

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	D6, 4; C4
2.	2	U	7	2	E3, 7
3.	3	U	7	3	H11, 5
4.	4	U	7	4	J7, 10
5.	5	U	7	5	L2
6.	6	U	7	6	M5, 11
7.	7	H	9	7	O8, 6, 7
8	8	H	5	1, 7	A10; O6
9.	9	H	4	4	J3

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:
Q = Question Number | B = Score Box Number | C = Cognitive Level
CO = Curriculum Organizer | K = Keyed Response | S = Score
PLO = Prescribed Learning Outcome

Physics 12
June 2004 Provincial Examination
ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	Sub-Organizers
1. Vector Kinematics in Two Dimensions	A, B
and	
Dynamics *and* Vector Dynamics	C, D
2. Work, Energy and Power	E
and	
Momentum	F, G
3. Equilibrium	H
4. Circular Motion	I
and	
Gravitation	J
5. Electrostatics	K, L
6. Electric Circuits	M, N
7. Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	A	K	2	1	A1	16.	D	H	2	4	I4; E8
2.	C	U	2	1	B8	17.	B	K	2	4	J4
3.	B	U	2	1	B8; E7	18.	B	U	2	4	J6
4.	D	K	2	1	C6	19.	D	K	2	5	L1
5.	D	U	2	1	C4, 8	20.	D	U	2	5	K5
6.	DELETED					21.	C	K	2	6	M7
7.	B	U	2	2	E6, 7	22.	C	U	2	6	M11
8.	A	U	2	2	E7, 8; D6	23.	D	H	2	6	N2; M7
9.	A	U	2	2	E2, 10	24.	D	K	2	7	O4
10.	D	U	2	2	G3	25.	A	U	2	7	O3
11.	DELETED					26.	B	U	2	7	O6
12.	C	U	2	3	H2, 3	27.	A	U	2	7	O8
13.	D	U	2	3	H5, 11	28.	C	U	2	7	P5
14.	B	U	2	4	I4; J2, 8	29.	C	U	2	7	P9
15.	C	U	2	4	I4; D5	30.	B	H	2	7	O5; C7; D5

Multiple Choice = 60 marks

4

Physics 12

August 2004 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	**Sub-Organizers**
1.	Vector Kinematics in Two Dimensions *and*	A, B
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power *and*	E
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion *and*	I
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	C	K	2	1	C3	16.	C	K	2	4	J3
2.	A	U	2	1	C8; D5	17.	B	U	2	4	J2, 3
3.	C	U	2	1	C4; D5	18.	A	U	2	4	J6, 7
4.	A	U	2	1	C4; B2	19.	D	K	2	5	K4, 8
5.	B	U	2	2	D5, 6; C4	20.	B	U	2	5	K5
6.	C	K	2	2	E6, 8	21.	C	U	2	5	L4
7.	B	U	2	2	E2, 7, 8	22.	B	K	2	6	M10, 11
8.	D	U	2	2	E10; A6	23.	A	U	2	6	M5, 6, 11
9.	A	H	2	2	E3, 8	24.	D	K	2	7	O7; L7
10.	A	K	2	3	H5	25.	D	U	2	7	O3
11.	B	U	2	3	H2, 3	26.	C	U	2	7	O6; I4
12.	A	U	2	3	H11	27.	B	U	2	7	P6
13.	B	K	2	4	I3	28.	C	U	2	7	P9
14.	C	U	2	4	I4; C8	29.	A	U	2	7	P11
15.	B	H	2	4	I4; J2	30.	D	H	2	7	P4, 5

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	9	1	C4, 8; D4
2.	2	U	7	2	G3
3.	3	U	7	3	H11, 5
4.	4	U	7	4	J9, 10; I4
5.	5	U	7	5	L8
6.	6	U	7	6	M6, 7; N2
7.	7	U	7	7, 1	O5; C7
8	8	H	5	1, 3	A10; H4
9.	9	H	4	5, 1	K2, 8; C4

Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	=	**120 marks**

LEGEND:

Q = Question Number	B = Score Box Number	C = Cognitive Level
CO = Curriculum Organizer	K = Keyed Response	S = Score
PLO = Prescribed Learning Outcome		

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	B7, 8
2.	2	U	9	2	F7, 2, 4
3.	3	U	7	3	H11, 5
4.	4	U	7	4	J7; E8
5.	5	U	7	5	L2, 6
6.	6	U	7	6	M5, 6; N2
7.	7	U	7	7	P5; M5
8	8	H	5	1, 4	A10; I4
9.	9	H	4	6	M11; N2

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 questions)
EXAMINATION TOTAL = 120 marks

LEGEND:
Q = Question Number | B = Score Box Number | C = Cognitive Level
CO = Curriculum Organizer | K = Keyed Response | S = Score
PLO = Prescribed Learning Outcome

WRITTEN

RESPONSE

ANSEWR

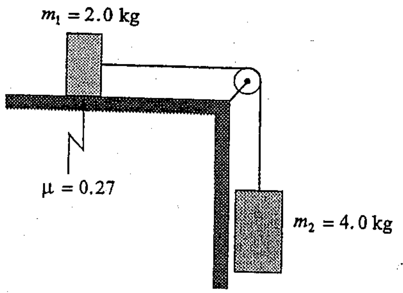
KEY

178

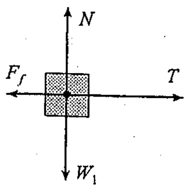
JANUARY 2000
WRITTEN RESPONSE

ANSWER KEY

1. Two masses are connected by a light string over a frictionless massless pulley. There is a coefficient of friction of 0.27 between mass m_1 and the horizontal surface.



a) Draw and label a free body diagram showing the forces acting on mass m_1. **(2 marks)**



← **2 marks**

b) What is the acceleration of mass m_2? **(5 marks)**

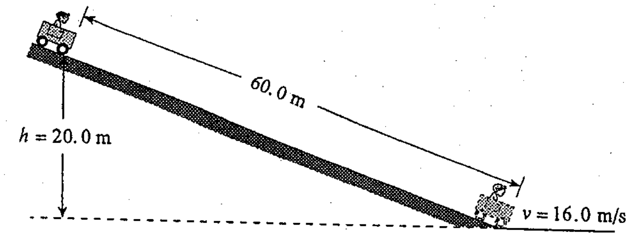
$a = \frac{F_{net}}{m}$ ← **½ mark**

$= \frac{m_2g - \mu m_1 g}{(m_1 + m_2)}$ ← **3½ marks**

$= \frac{4.0\text{ kg}(9.8\text{ N/kg}) - (0.27)(2.0\text{ kg})(9.8\text{ N/kg})}{(2.0\text{ kg} + 4.0\text{ kg})}$ ← **½ mark**

$= 5.7\text{ m/s}^2$ ← **½ mark**

2. A 170 kg cart and rider start from rest on a 20.0 m high incline.



a) How much energy is transformed to heat? **(5 marks)**

$\Delta E = 0$

$Ep = E_k + Heat$ ← **2 marks**

$mgh = \frac{1}{2}mv^2 + Heat$ ← **1 mark**

$170(9.8)20.0 = \frac{1}{2}(170)16.0^2 + E_h$ ← **1 mark**

$33\,320 = 21\,760 + E_h$

$1.16 \times 10^4\text{ J} = E_h$ ← **1 mark**

b) What is the average force of friction acting on the cart? **(2 marks)**

E_h = work done by friction

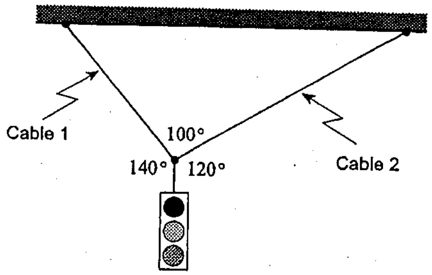
$11560 = F_f \cdot d$

$\therefore F_f = \frac{11\,560}{60.0}$

$F_f = 193$ N

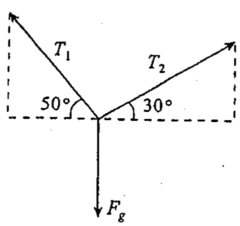
$F_f = 190$ N ← **2 marks**

3. A 35 kg traffic light is suspended from two cables as shown in the diagram.



What is the tension in each of these cables? (7 marks)

Component Method:



← **2 marks**

$$\Sigma F_x = 0$$

$$T_1 \cos 50° = T_2 \cos 30°$$

$$T_1 = T_2 \frac{\cos 30°}{\cos 50°}$$

$$\Sigma F_y = 0$$

$$T_1 \sin 50° + T_2 \sin 30° = 35(9.8)$$

$$\left(T_2 \frac{\cos 30°}{\cos 50°}\right) \sin 50° + T_2 \sin 30° = 343$$

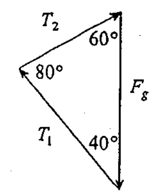
$$T_2 = \frac{343}{1.03 + 0.5}$$

$$T_2 = 224 \text{ N}$$

$$T_1 = 224 \frac{\cos 30°}{\cos 50°}$$

$$= 302 \text{ N}$$

Vector Method:



← **3 marks**

$$\frac{\sin 80°}{F_g} = \frac{\sin 60°}{T_1}$$

$$T_1 = \frac{\sin 60°}{\sin 80°} \cdot F_g$$

$$= 0.879 \cdot 35 \text{ kg} \cdot 9.8 \text{ m/s}^2$$

$$= 3.0 \times 10^2 \text{ N}$$

$1\frac{1}{2}$ marks

$F = mg = (35 \text{ kg})(9.8 \text{ N/kg}) = 343 \text{ N}$ ← **1 mark**

$$\frac{\sin 80°}{F_g} = \frac{\sin 40°}{T_2}$$

$$T_2 = 2.2 \times 10^2 \text{ N}$$

$1\frac{1}{2}$ marks

4. A 5.0 kg rock dropped near the surface of Mars reaches a speed of 15 m/s in 4.0 s.

a) What is the acceleration due to gravity near the surface of Mars? **(2 marks)**

$a = \frac{\Delta v}{\Delta t}$ ← **1 mark**

$= \frac{15}{4.0}$ ← **$\frac{1}{2}$ mark**

$= 3.8 \text{ m/s}^2$ ← **$\frac{1}{2}$ mark**

OR

$d = v_{ave} \times t$

$= 7.5 \times 4 = 30 \text{ m}$ ← **$\frac{1}{2}$ mark**

$v^2 = v_0^2 + 2ad$ ← **1 mark**

$15^2 = 2(a)(30)$

$a = 3.8 \text{ m/s}^2$ ← **$\frac{1}{2}$ mark**

b) Mars has an average radius of 3.38×10^6 m. What is the mass of Mars? **(5 marks)**

$F_g = \frac{GMm}{R^2}$ ← **1 mark**

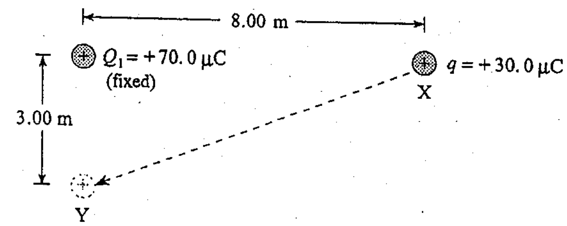
$\cancel{m}g = \frac{GM\cancel{m}}{R^2}$ ← **1 mark**

$\therefore M = \frac{gR^2}{G}$ ← **1 mark**

$= \frac{3.8 \times (3.38 \times 10^6)^2}{6.67 \times 10^{-11}}$ ← **1 mark**

$= 6.5 \times 10^{23} \text{ kg}$ ← **1 mark**

5. A charge q of $30.0\ \mu\text{C}$ is moved from point X to point Y.



How much work is done on the $30.0\ \mu\text{C}$ charge? $(1\ \mu C = 1 \times 10^{-6}\ \text{C})$ **(7 marks)**

$W = \Delta E$ ← **1 mark**

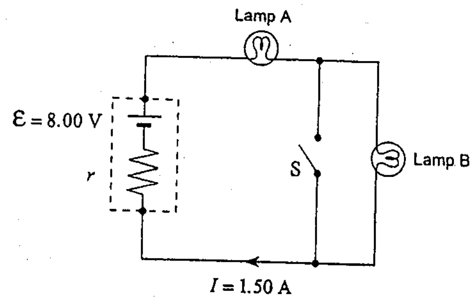
$= E_{p_y} - E_{p_x}$ ← **2 marks**

$= \frac{kQq}{r_y} - \frac{kQq}{r_x}$ ← **1 mark**

$$\left.\begin{aligned} &= \frac{9.00 \times 10^9 \cdot 70.0 \times 10^{-6} \cdot 30.0 \times 10^{-6}}{3.00} - \frac{9.00 \times 10^9 \cdot 70.0 \times 10^{-6} \cdot 30.0 \times 10^{-6}}{8.00} \\ &= (6.3 - 2.4)\ \text{J} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$= 3.9$ J ← **1 mark**

6. The circuit shown consists of an 8.00 V battery and two light bulbs. Each light bulb dissipates 5.0 W. Assume that the light bulbs have a constant resistance. Switch S is open.



a) If a current of 1.50 A flows in the circuit, what is the internal resistance r of the battery? (4 marks)

Resistance Solution:

$P = I^2 R$

$\therefore R_{bulb} = \frac{P}{I^2}$

$= \frac{5.0}{(1.50)^2}$

$= 2.22\ \Omega$ ← **1 mark**

$R_T = \frac{\mathcal{E}}{I}$

$= \frac{8.00}{1.50}$

$= 5.33\ \Omega$ ← **1 mark**

$\therefore r = R_T - 2\cdot(R_{bulb})$

$= 5.33 - 2(2.22)$ ← **1 mark**

$= 0.89\ \Omega$ ← **1 mark**

Voltage Solution:

$\left.\begin{array}{r} P = IV \\ 5 = 1.5\,V \\ V_{bulb} = 3.3\text{ V} \end{array}\right\}$ ← **1 mark**

$\left.\begin{array}{r} V_{terminal} = 3.3\times 2 \\ V_{terminal} = 6.7 \end{array}\right\}$ ← **1 mark**

$\left.\begin{array}{r} V_{terminal} = \mathcal{E} - Ir \\ 6.7 = 8 - 1.5r \end{array}\right\}$ ← **1 mark**

$r = 0.89\ \Omega$ ← **1 mark**

Power Solution:

$P_T = IV$

$= 1.5(8)$

$= 12$ W ← **1 mark**

$P_{bulbs} = 2(5) = 10$ ← **1 mark**

$P_r = 12 - 10$ ← **1 mark**

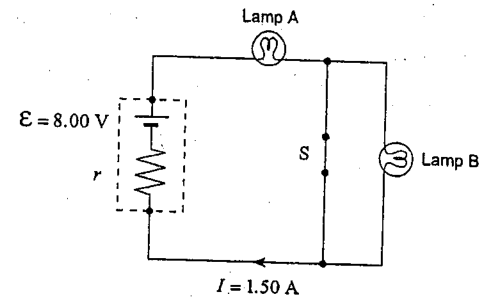
$P_r = 2$ W

$P = I^2 R$

$r = \frac{2}{1.5^2}$

$= 0.89\ \Omega$ ← **1 mark**

b) The switch S is now closed. **DELETED**



Lamp A will now be **(1 mark)**

i) ☑ brighter.
☐ the same brightness as before.
☐ dimmer.

(Check one response.)

The battery's terminal voltage will now be **(1 mark)**

ii) ☐ greater than before.
☐ the same as before.
☑ less than before.

(Check one response.)

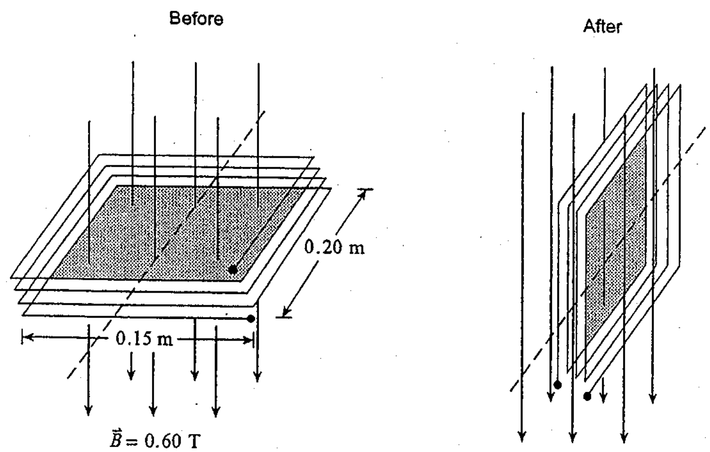
c) Using principles of physics, explain your answers to b). **DELETED** (3 marks)

Total circuit resistance decreases when the switch is closed. Therefore, the circuit current increases. ← 1 mark

Since $P = I^2R$, the power dissipated by Lamp A increases and it will therefore be brighter. ← 1 mark

Since the circuit current has increased, the voltage drop across the internal resistance increases and the terminal voltage drops. ← 1 mark

7. The diagram shows a coil with 25 windings and dimensions 0.15 m by 0.20 m. Its plane is perpendicular to a magnetic field of magnitude 0.60 T.



If the coil rotates 90° in 4.17×10^{-2} s so that its plane is now parallel to the magnetic field, what average emf is induced during this time? (7 marks)

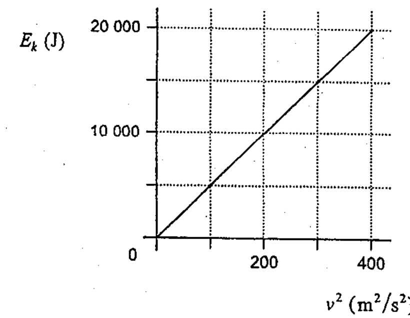
$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$ (ignore direction term) ← **2 marks**

$$\mathcal{E} = \frac{N\times\Delta\Phi}{\Delta t}$$
$$= \frac{N\times(\Phi' - \Phi)}{\Delta t}$$
$$= \frac{N\times(0 - BA)}{\Delta t}$$
$$= \frac{25\times0.60\times0.15\times0.20}{4.17\times10^{-2}}$$ ← **4 marks**

$= 10.8$ V

$= 11$ V ← **1 mark**

8. A student plots the graph below, showing the kinetic energy E_k of a motorbike versus the square of its velocity v^2.



a) What is the slope of this graph? **(2 marks)**

$$slope = \frac{\Delta E_k}{\Delta v^2}$$
$$= \frac{20\ 000 \text{ J}}{400 \text{ m}^2/\text{s}^2}$$
$$= 50 \text{ J/m}^2/\text{s}^2$$ ← **2 marks**

or 50 kg

b) What does the slope represent? **(2 marks)**

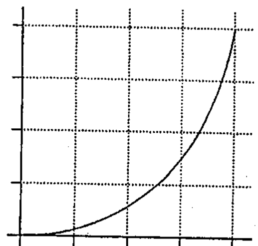
From the graph: $E_k = kv^2$, $\therefore (E_k = 50\ v^2)$ ← **1 mark**

But $E_k = \frac{1}{2}mv^2$, **therefore the slope represents one half the mass of the motorbike.** ← **1 mark**

8

c) Using the axes below, sketch the graph of kinetic energy E_k versus velocity v for this motorbike. There is no need to plot any data points. **(1 mark)**

E_k (J)



0

v (m/s)

$\leftarrow$ **1 mark**

9. A classmate insists a book cannot be held against a wall by pushing horizontally as shown in Diagram A. He insists that there must be a vertical force component, provided by pushing against the book from below, as shown in Diagram B.

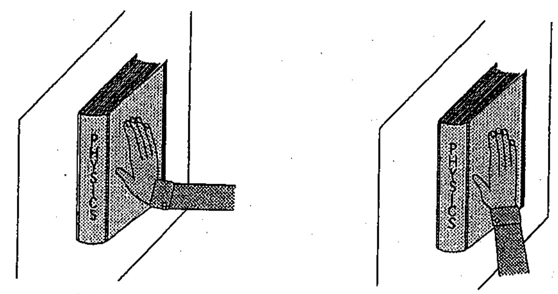


Diagram A Diagram B

Using principles of physics, show that the situation in Diagram A is reasonable. **(4 marks)**

A normal force opposite to the applied force exists. i.e., Newton's third law. $\leftarrow$ **1 mark**
Some friction force $\left(F_f\right)$ exists. $\leftarrow$ **1 mark**
The friction force depends on the normal force. $\leftarrow$ **1 mark**
With a sufficiently large enough applied force the friction force can oppose the force of gravity. $\leftarrow$ **1 mark**

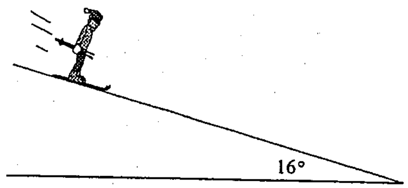
END OF KEY

8

JUNE 2000 ANSWER KEY

WRITTEN RESPONSE

1. A 75 kg Olympic skier takes 20 s to reach a speed of 25 m/s from rest while descending a uniform 16° slope.



What is the coefficient of friction between the skis and the slope surface? **(7 marks)**

$$a = \frac{\Delta v}{\Delta t}$$

$$= \frac{25 \text{ m/s}}{20 \text{ s}}$$

$$= 1.25 \text{ m/s}^2 \qquad \leftarrow \textbf{2 marks}$$

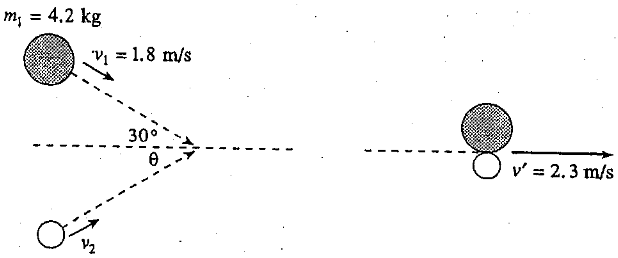
$$\left.\begin{aligned} ma &= mg\sin\theta - \mu mg\cos\theta \\ a &= g\sin\theta - \mu g\cos\theta \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

$$\mu = \frac{g\sin\theta - a}{g\cos\theta} \qquad \leftarrow \textbf{1 mark}$$

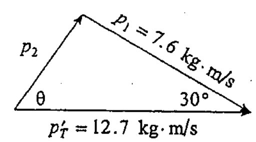
$$= \frac{9.8 \text{ m/s}^2 \cdot \sin 16° - 1.25 \text{ m/s}^2}{9.8 \text{ m/s}^2 \cdot \cos 16°}$$

$$= 0.15 \qquad \leftarrow \textbf{1 mark}$$

2. Two steel pucks are moving as shown in the diagram. They collide inelastically.



Determine the speed and direction (angle θ) of the 1.3 kg puck before the collision. **(7 marks)**



$$\left.\begin{aligned} p_1 &= m_1 v_1 \\ &= 4.2 \times 1.8 \\ &= 7.6 \text{ kg}\cdot\text{m/s} \\ p'_T &= m_T v'_1 \\ &= 5.5 \times 2.3 \\ &= 12.7 \text{ kg}\cdot\text{m/s} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

Method 1:

Cosine Law:

$$p_2^2 = (p'_T)^2 + p_1^2 - 2p'_T p_1 \cos 30°$$

$$= 12.7^2 + 7.6^2 - 2 \times 12.7 \times 7.6 \times \cos 30°$$

$$p_2^2 = 51.9$$

$$p_2 = \sqrt{51.9} = 7.20 \text{ kg m/s} \qquad \leftarrow \textbf{3 marks}$$

$$v_2 = \frac{p_2}{m_2} = \frac{7.20 \text{ kg m/s}}{1.3 \text{ kg}} = 5.5 \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

Sine Law:

$$\left.\begin{aligned}\frac{\sin\theta}{7.6} &= \frac{\sin 30°}{7.2}\\ \sin\theta &= \frac{7.6\times\sin 30°}{7.2}\\ \sin\theta &= 0.528\\ \theta &= 32°\end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$v_2 = 5.5$ m/s at 32°

Method 2: **(one variation)**

$m_1v_1\cos 30° + m_2v_2\cos\theta = m_Tv'$ $\leftarrow$ **1 mark**

$4.2(1.8)\cos 30° + 1.3(v_2)\cos\theta = (4.2+1.3)(2.3)$ $\leftarrow$ **1 mark**

$v_2 = \dfrac{4.69}{\cos\theta}$ $\leftarrow$ **1 mark**

$m_1v_1\sin 30° + m_2v_2\sin\theta = 0$ $\leftarrow$ **1 mark**

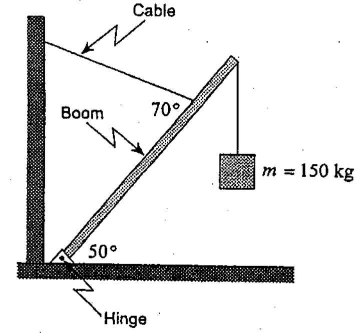
$4.2(1.8)\sin 30° + 1.3(v_2)\sin\theta = 0$ $\leftarrow$ **1 mark**

$v_2 = \dfrac{2.91}{\sin\theta}$

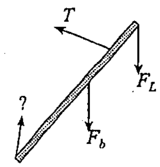
$$\left.\begin{aligned}\frac{4.69}{\cos\theta} &= \frac{2.91}{\sin\theta}\\ \frac{\sin\theta}{\cos\theta} &= \frac{2.91}{4.69}\\ \tan\theta &= 0.618\\ \theta &= 32°\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned}v_2 &= \frac{4.69}{\cos 31.8}\\ v_2 &= 5.5\ \text{m/s}\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

3. A uniform 6.0 m-long boom has a mass of 55 kg. It is kept in position by a restraining cable attached three-quarters of the way along the boom.



What is the tension in this cable when the boom supports a 150 kg mass as shown? **(7 marks)**



About the hinge:

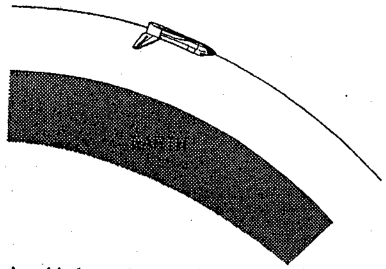
$\Sigma\tau = 0$ $\leftarrow$ **1 mark**

$\tau_{cable} - \tau_{mass} - \tau_{boom} = 0$ $\leftarrow$ **1 mark**

$(T\cos 20)\left(\frac{3}{4}\cdot 6\right) - (150(9.8)\cos 50)(6) - (55(9.8)\cos 50)\left(\frac{1}{2}\cdot 6\right) = 0$ $\leftarrow$ **4 marks**

$T = 1\,600$ N $\leftarrow$ **1 mark**

4. A space shuttle is placed in a circular orbit at an altitude of 3.00×10^5 m **above** Earth's surface.



a) What is the shuttle's orbital speed? **(5 marks)**

$F_c = F_g$ ← **1 mark**

$$m\frac{v^2}{R} = \frac{GMm}{R^2}$$

$$v^2 = \frac{GM}{R}$$

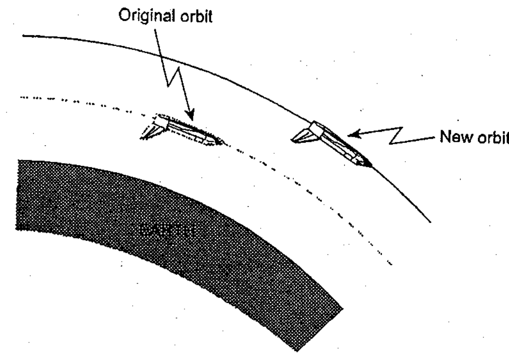
$$v = \sqrt{\frac{GM}{R}}$$

← **2 marks**

$$= \sqrt{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.68 \times 10^6}}$$ ← **1 mark**

$v = 7.73 \times 10^3$ m s ← **1 mark**

b) The space shuttle is then moved to a higher orbit in order to capture a satellite.



The shuttle's speed in this new higher orbit will have to be

- ☐ greater than in the lower orbit.
- ☑ less than in the lower orbit.
- ☐ the same as in the lower orbit.

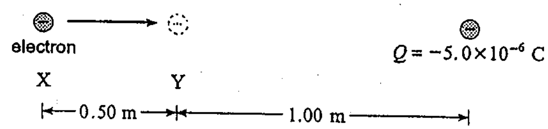
(Check one response.) **(1 mark)**

c) Using principles of physics, explain your answer to b). **(3 marks)**

As the space shuttle moves further away from the earth's centre the force of gravity acting on the shuttle decreases. Since the centripetal force is provided by the force of gravity, it must decrease as well. ← 2 marks

The smaller centripetal force generates a smaller centripetal acceleration ← 1 mark which in turn requires a smaller orbital velocity.

5. a) How much work is done in moving an electron from point X to point Y? **(5 marks)**



$W = \Delta Ep$

$$= \frac{kQq}{r_2} - \frac{kQq}{r_1} \quad \Big\}\leftarrow \textbf{2 marks}$$

$$= \frac{9.0\times10^{9}\times-5.0\times10^{-6}\times-1.60\times10^{-19}}{1.00} - \frac{9.0\times10^{9}\times-5.0\times10^{-6}\times-1.60\times10^{-19}}{1.50} \quad \leftarrow \textbf{2 marks}$$

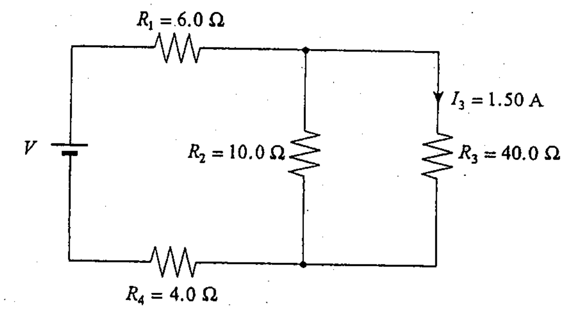
$$= 2.4\times10^{-15}\ J \quad \leftarrow \textbf{1 mark}$$

b) What is the potential difference between point X and point Y? **(2 marks)**

$$\Delta V = \frac{W}{q} = 1.5\times10^{4}\ \text{V} \quad \leftarrow \textbf{2 marks}$$

Note: Both positive and negative answers will be accepted for b).

6. A current of 1.50 A flows through the 40.0 Ω resistor.



What is the potential difference of the power supply? **(7 marks)**

$$\left.\begin{aligned} V_3 &= I_3R \\ &= 1.50(40.0) \\ V_3 &= 60.0\ \text{V} \\ V_2 &= V_3 = 60.0\ \text{V} \end{aligned}\right\}\leftarrow \textbf{2 marks}$$

$$I_2 = \frac{V_2}{R_2} = \frac{60.0}{10.0} = 6.00\ \text{A} \quad \leftarrow \textbf{1 mark}$$

$$I_t = I_3 + I_2 = 1.50 + 6.00 = 7.50\ \text{A} \quad \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_1 &= I_1R_1 \\ V_1 &= 7.50(6.0) \\ V_1 &= 45\ \text{V} \end{aligned}\right\}\leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_4 &= I_4R_4 \\ &= 7.50(4.0) \\ V_4 &= 30\ \text{V} \end{aligned}\right\}\leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_t &= V_b = V_1 + V_{||} + V_4 \\ &= 45 + 60 + 30 \\ V_b &= 135\ \text{V} \end{aligned}\right\}\leftarrow \textbf{1 mark}$$

Alternate Solution:

$$\left.\begin{aligned} V_3 &= I_3 R \\ &= 1.50(40.0) \\ V_3 &= 60.0\text{ V} \\ V_2 &= V_3 = 60.0\text{ V} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$I_2 = \frac{V_2}{R_2} = \frac{60.0}{10.0} = 6.00\text{ A} \qquad \leftarrow \textbf{1 mark}$$

$$I_t = I_3 + I_2 = 1.50 + 6.00 = 7.50\text{ A} \qquad \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} R_p &= \frac{1}{\frac{1}{R_3}+\frac{1}{R_2}} = \frac{1}{\frac{1}{40.0}+\frac{1}{10.0}} \\ &= 8.00\ \Omega \\ R_T &= 6.0\ \Omega + 8.0\ \Omega + 4.0\ \Omega \\ &= 18.0\ \Omega \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} V_0 &= (I_0)(R_T) \\ &= (7.50)(18.0) = 135\text{ V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

7. A transformer has 840 primary and 56 secondary windings. The primary coil is connected to a 110 V ac power supply which delivers a 0.30 A current to the transformer.

   a) Find the secondary voltage. **(4 marks)**

$$\left.\begin{aligned} \frac{V_s}{V_p} &= \frac{N_s}{N_p} \\ \frac{V_s}{110} &= \frac{56}{840} \\ V_s &= 7.3\text{ V} \end{aligned}\right\} \leftarrow \textbf{4 marks}$$

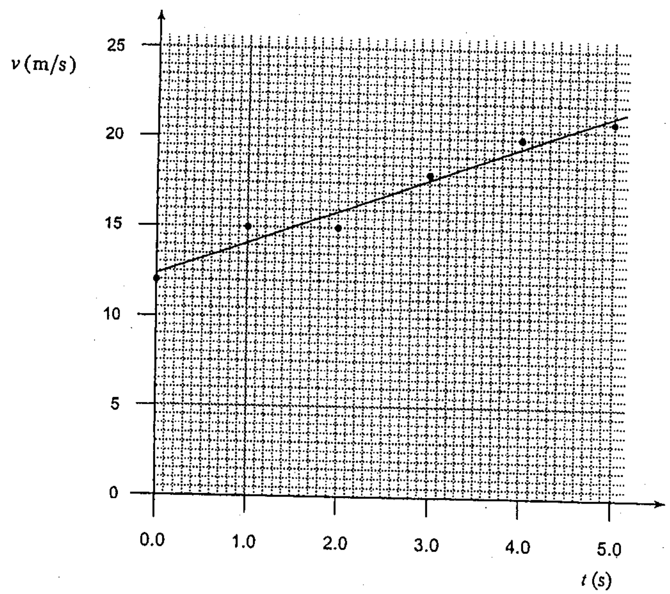
   b) Find the secondary current. **(3 marks)**

$$\left.\begin{aligned} \frac{I_p}{I_s} &= \frac{N_s}{N_p} \\ \frac{0.30}{I_s} &= \frac{56}{840} \\ I_s &= 4.5\text{ A} \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

8. The data table shows the velocity of a car during a 5.0 s interval.

t (s)	0.0	1.0	2.0	3.0	4.0	5.0
v (m/s)	12	15	15	18	20	21

a) Plot the data and draw a best-fit straight line. **(2 marks)**



b) Calculate the area bounded by the graph and the time axis between $t = 0.0$ s and $t = 5.0$ s. **(2 marks)**

$Area = \frac{1}{2}(a+b)c$

$\cong 85$ m ← **2 marks**

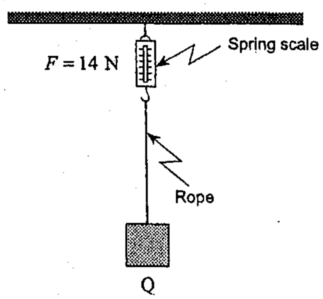
c) What does this area represent? **(1 mark)**

The area represents the distance (displacement) travelled by the car in the time $t = 0$ to $t = 5$ s.

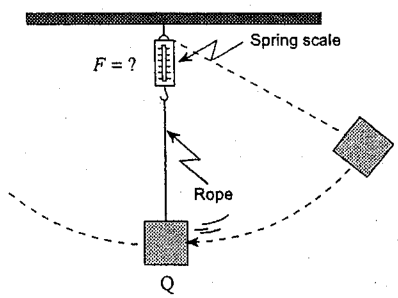
"Metres" only ← $\frac{1}{2}$ mark

19

9. A mass is suspended by a string attached to a spring scale that initially reads 14 N as shown in Diagram 1.



The mass is pulled to the side and then released as shown in Diagram 2.



As the mass passes point Q, how will the reading on the spring scale compare to the previous value of 14 N? Using principles of physics, explain your answer. **(4 marks)**

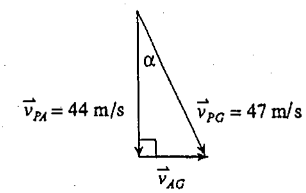
The reading will be greater than 14 N. $\left(\text{by } \frac{mv^2}{r}\right)$ **← 1 mark**

Initially, the net force is zero, so the spring scale reads the weight of the mass. When moving, there is a net (centripetal) force provided by the spring scale (tension in the rope) which exceeds the weight (force of gravity) of the mass so that the mass goes in a vertical circle. ← 3 marks

END OF KEY

1. An aircraft heads due south with a speed relative to the air of 44 m/s. Its resultant speed over the ground is 47 m/s. The wind blows from the west.

   a) What is the speed of the wind? **(4 marks)**



← 2 marks for diagram

$$\left.\begin{aligned} v_{PA}^2 + v_{AG}^2 &= v_{PG}^2 \\ 44^2 + v_{AG}^2 &= 47^2 \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$v_{AG} = 16.5 \text{ m/s}$$

$$v_{AG} = 17 \text{ m/s} \quad \leftarrow \textbf{1 mark}$$

   b) What is the direction of the aircraft's path over the ground? **(3 marks)**

$$\cos\alpha = \frac{44}{47} \quad \leftarrow \textbf{1}\tfrac{1}{2}\textbf{ marks}$$

$$\alpha = 20.6°$$

$$= \underbrace{21°}_{\textbf{1 mark}} \ \underbrace{\text{east of south}}_{\frac{1}{2}\textbf{ mark}}$$

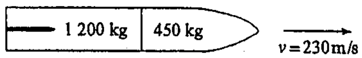
or

69° south of east

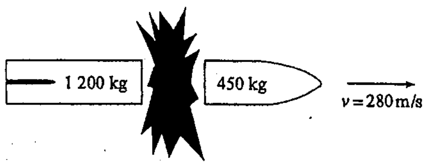
or

south 21° east

2. A space vehicle made up of two parts is travelling at 230 m/s as shown.



An explosion causes the 450 kg part to separate and travel with a final velocity of 280 m/s as shown.



a) What was the momentum of the space vehicle before the explosion? **(2 marks)**

$$p = mv$$
$$= (1\,200 + 450)230$$
$$= 3.8 \times 10^5 \text{ kg m/s} \quad \leftarrow \textbf{2 marks}$$

b) What was the magnitude of the impulse on the 1 200 kg part during the separation? **(3 marks)**

$$Impulse = \Delta p$$
$$= P_b - P_a \quad \leftarrow \textbf{1 mark}$$
$$= (450 \times 280) - (450 \times 230) \quad \leftarrow \textbf{1 mark}$$
$$= 2.3 \times 10^4 \text{ N} \cdot \text{s} \quad \leftarrow \textbf{1 mark}$$

c) Using principles of physics, explain what changes occur, if any, to the

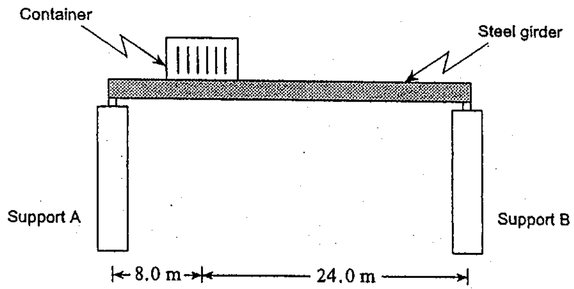
i) momentum of the system as a result of the explosion. **(2 marks)**

In an explosion, momentum must be conserved.

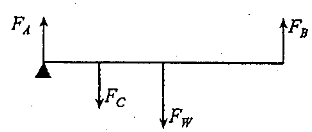
ii) kinetic energy of the system as a result of the explosion. **(2 marks)**

Since the explosion adds energy to the system, the system will gain kinetic energy.

3. A uniform 1 200 kg steel girder is supported horizontally at its endpoints as shown in the diagram.



What are the upward forces at the girder end points when it is bearing a 3 700 kg shipping container 8.0 m from support A? **(7 marks)**



Pivot A (4 marks for first pivot calculation):

$$\Sigma\tau_{cw} = \Sigma\tau_{ccw} \qquad \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} F_C L_C + F_W L_W &= F_B L_B \\ 3700(9.8)(8) + 1200(9.8)(16) &= F_B(32) \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$2.90\times10^5 + 1.88\times10^5 = F_B(32)$$

$$1.49\times10^4 \text{ N} = F_B \qquad \leftarrow \textbf{1 mark}$$

Pivot B (3 marks for second pivot **OR** sum of forces):

$$\left.\begin{aligned} F_C L_C + F_W L_W &= F_A L_A \\ 3700(9.8)(24) + 1200(9.8)(16) &= F_A(32) \\ \left(8.70\times10^5\right) + \left(1.88\times10^5\right) &= F_A(32) \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

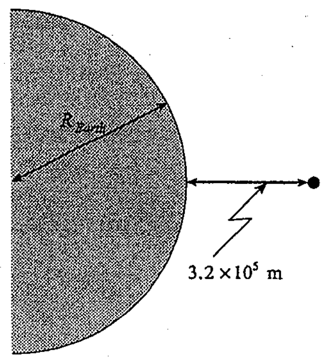
$$3.31\times10^4 \text{ N} = F_A \qquad \leftarrow \textbf{1 mark}$$

Forces:

$$\left.\begin{aligned} F_C + F_W &= F_A + F_B \\ 3700(9.8) + 1200(9.8) &= F_A + F_B \\ \left(3.63\times10^4\right) + \left(1.18\times10^4\right) &= F_A + F_B \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$F_A \text{ or } F_B = \qquad \leftarrow \textbf{1 mark}$$

4. A 4.00×10^3 kg object is lifted from the earth's surface to an altitude of 3.2×10^5 m. How much work does this require? **(7 marks)**



(Diagram not to scale.)

$R_1 = 6.38 \times 10^6$ m

$R_2 = 6.38 \times 10^6 \text{ m} + 3.2 \times 10^5$ m

$\quad = 6.70 \times 10^6$ m $\qquad \leftarrow$ **1 mark**

$W = \Delta E$ $\qquad \leftarrow$ **1 mark**

$$\Delta Ep = Ep_2 - Ep_1$$

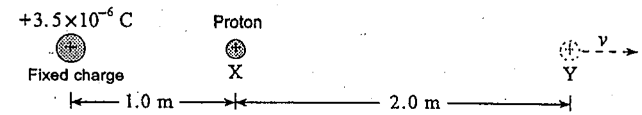
$$= \frac{-GMm}{R_2} - \left(-\frac{GMm}{R_1}\right) \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{-6.67 \times 10^{-11} \cdot 5.98 \times 10^{24} \cdot 4.00 \times 10^3}{6.70 \times 10^6} - \frac{-6.67 \times 10^{-11} \cdot 5.98 \times 10^{24} \cdot 4.00 \times 10^3}{6.38 \times 10^6} \qquad \leftarrow \textbf{2 marks}$$

$$= -2.38 \times 10^{11} \text{ J} - \left(-2.50 \times 10^{11} \text{ J}\right) \qquad \leftarrow \textbf{1 mark}$$

$$\Delta Ep = 1.2 \times 10^{10} \text{ J} \qquad \leftarrow \textbf{1 mark}$$

5. A proton, initially at rest at point X, will have what speed at point Y? **(7 marks)**



$$\left.\begin{aligned} \Delta E &= 0 \\ \Delta E_k &= -\Delta Ep \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$E_{k_2} - E_{k_1} = E_{p_1} - E_{p_2}$$

$$\tfrac{1}{2} m v_2{}^2 - 0 = \frac{kQq}{r_1} - \frac{kQq}{r_2} \qquad \leftarrow \textbf{3 marks}$$

$$= \frac{9.0 \times 10^9 \cdot 3.5 \times 10^{-6} \cdot 1.6 \times 10^{-19}}{1.0} - \frac{9.0 \times 10^9 \cdot 3.5 \times 10^{-6} \cdot 1.6 \times 10^{-19}}{3.0} \qquad \leftarrow \textbf{2 marks}$$

$$= \frac{5.04 \times 10^{-15}}{1} - \frac{5.04 \times 10^{-15}}{3}$$

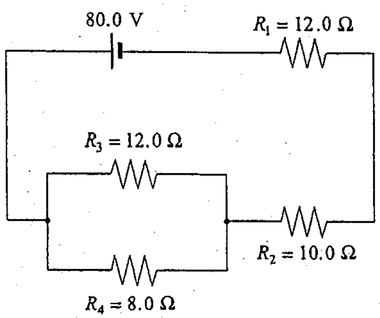
$$= 5.04 \times 10^{-15} - 1.68 \times 10^{-15}$$

$$\tfrac{1}{2} m v^2 = 3.36 \times 10^{-15}$$

$$\tfrac{1}{2}\left(1.67 \times 10^{-27}\right) v^2 = 3.36 \times 10^{-15}$$

$$v = 2.0 \times 10^6 \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

6. What is the power dissipated in the $8.0\ \Omega$ resistor in the circuit as shown? **(7 marks)**



$$\frac{1}{R_{\parallel}} = \frac{1}{R_3} + \frac{1}{R_4}$$

$$= \frac{1}{12.0} + \frac{1}{8.0}$$

$R_{\parallel} = 4.8\ \Omega$ ← **1 mark**

$R_t = R_1 + R_2 + R_{\parallel}$

$= (12.0 + 10.0 + 4.8)$

$R_t = 26.8\ \Omega$ ← **1 mark**

$I_t = \frac{V_t}{R_t} = \frac{80.0}{26.8} = 2.99\ \text{A}$ ← **2 marks**

$V_1 = I_t R_1 = 2.99(12) = 35.9\ \text{V}$

$V_2 = I \cdot R_2 = 2.99(10) = 29.9\ \text{V}$

$V_{\parallel} = 80.0 - (35.9 + 29.9)$

$= 14.3\ \text{V}$ ← **2 marks**

$P = \frac{V^2}{R} = \frac{14.3^2}{8.0} = 26\ \text{W}$ ← **1 mark**

7. The magnetic field at the centre of a solenoid of length 0.25 m is 1.2×10^{-2} T. The current in the windings is 7.5 A.

a) How many windings does the solenoid have? **(4 marks)**

$B = \mu_0 \left(\frac{N}{\ell}\right) I$ ← **1 mark**

$$\left.\begin{aligned} N &= \frac{B\ell}{\mu_0 \cdot I} \\ &= \frac{(1.2 \times 10^{-2})(0.25)}{(4\pi \times 10^{-7})(7.5)} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$= 318$

$= 3.2 \times 10^2$ ← **1 mark**

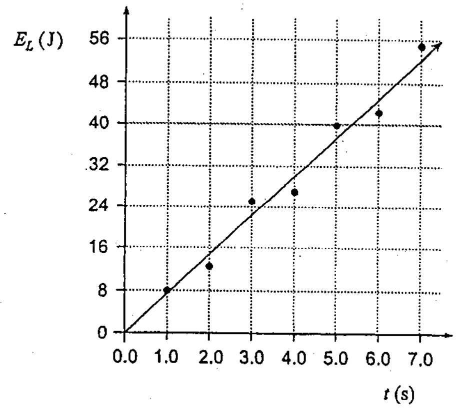
b) If the cross-sectional area of the solenoid is $8.5 \times 10^{-4}\ \text{m}^2$, what is the flux through it? **(3 marks)**

$\Phi = BA$ ← **1 mark**

$= (1.2 \times 10^{-2})(8.5 \times 10^{-4})$ ← **1 mark**

$= 1.0 \times 10^{-5}$ Wb ← **1 mark**

8. The graph shows the light energy E_L emitted by a bulb versus time t.



a) Find the power output of the bulb. **(2 marks)**

$P = \frac{\Delta E}{\Delta t}$ ← **1 mark**

$\cong 7.6$ W ← **1 mark**

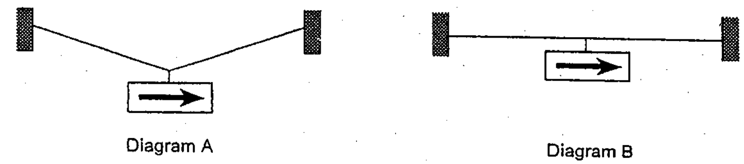
b) If this bulb is 20% efficient, find the power delivered to the bulb. **(3 marks)**

$\frac{P_{out}}{P_{in}} = 0.20$

$\frac{7.6}{P_{in}} = 0.20$

$P_{in} \cong 38$ W ← **3 marks**

9. In your summer job with the Ministry of Transportation and Highways your supervisor has told you that street signs should no longer be suspended as shown in Diagram A. In order to save money, he would prefer a shorter, perfectly horizontal cable, as shown in Diagram B.



Using principles of physics, argue that the situation in Diagram B is not reasonable. **(4 marks)**

To balance the weight of the sign there must be an upward force. ← 2 marks

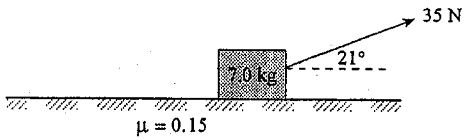
In Diagram B there is no vertical component of the cable tension, and hence no upward force to oppose the weight of the sign. ← 2 marks

END OF KEY

JANUARY 2001
WRITTEN RESPONSE

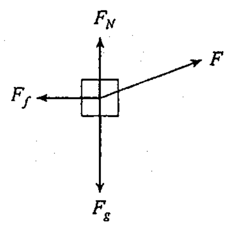
ANSWER KEY

1. A 35 N force applied at 21° to the horizontal is used to pull a mass as shown.



The coefficient of friction between the floor and the mass is 0.15.

a) Draw and label a free body diagram showing the forces acting on the mass. **(2 marks)**



← $\frac{1}{2}$ **mark for each vector**

b) What is the acceleration of the mass? **(5 marks)**

$$a = \frac{F_{net}}{m} \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$F_{net} = F_x - F_f$$

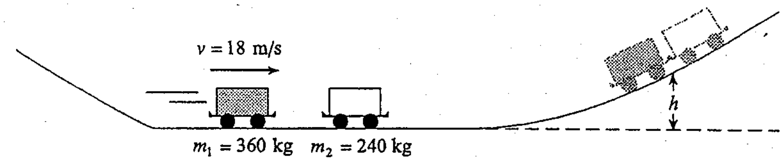
$$= 35 \times \cos 21° - 0.15(7.0 \times 9.8 - 35 \times \sin 21°) \qquad \leftarrow \textbf{4 marks}$$

$$= 32.68 - 8.41$$

$$F_{net} = 24.3 \text{ N}$$

$$a = \frac{24.3 \text{ N}}{7.0 \text{ kg}} = 3.5 \text{ m/s}^2 \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

2. A 360 kg roller coaster car travelling at 18 m/s collides inelastically with a stationary 240 kg car on a section of horizontal track as shown in the diagram below.



To what maximum height, h, do the combined cars travel before rolling back down the hill? (Assume no friction.) **(7 marks)**

$$V_{combined} = \frac{m_1 v_1}{m_1 + m_2}$$

$$= \frac{360 \cdot 18}{360 + 240}$$

$$= 10.8 \text{ m/s} \qquad \leftarrow \textbf{3 marks}$$

$$E_{k_{combined}} = \frac{1}{2} mv^2$$

By conservation of energy:

$$mgh = \frac{1}{2} mv^2 \qquad \leftarrow \textbf{2 marks}$$

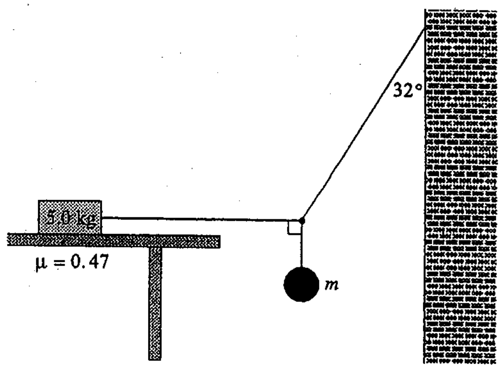
$$\therefore h = \frac{v^2}{2g}$$

$$= \frac{(10.8)^2}{2 \cdot 9.8}$$

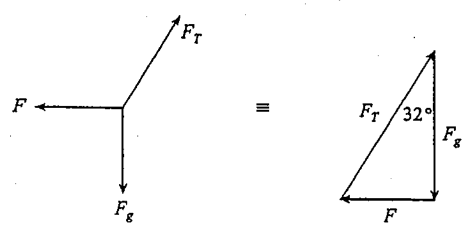
$$= 5.95 \text{ m}$$

$$= 6.0 \text{ m} \qquad \leftarrow \textbf{2 marks}$$

3. An object of mass, m, is suspended by two cords connected to a wall and to a 5.0 kg block resting on a table as shown.



A coefficient of friction of 0.47 exists between the 5.0 kg block and the table. What is the maximum mass, m, that can be hung from the cords before the 5.0 kg block begins to move?
(7 marks)



$$F_f = \mu F_N$$

$$= 0.47 \times 5.0 \times 9.8$$

$$= 23\text{ N} \qquad \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} F_g &= \frac{F}{\tan 32^\circ} \\ mg &= \frac{F}{\tan 32^\circ} \\ m &= \frac{F}{g \times \tan 32^\circ} \\ m &= \frac{23}{9.80 \times \tan 32^\circ} \end{aligned}\right\} \leftarrow \textbf{4 marks}$$

$$m = 3.8\text{ kg} \qquad \leftarrow \textbf{1 mark}$$

4. a) Mars has a mass of 6.37×10^{23} kg and a radius of 3.43×10^{6} m. What is the gravitational field strength on its surface?
(4 marks)

$$g = \frac{GM}{r^2} \qquad \leftarrow \textbf{2 marks}$$

$$= \frac{6.67 \times 10^{-11}\left(6.37 \times 10^{23}\right)}{\left(3.43 \times 10^{6}\right)^2} \qquad \leftarrow \textbf{1 mark}$$

$$= 3.61\text{ N/kg} \qquad \leftarrow \textbf{1 mark}$$

b) What thrust force must the rocket engine of a Martian lander exert if the 87.5 kg spacecraft is to accelerate upwards at 1.20 m/s^2 as it leaves the surface of Mars?
(3 marks)

$$F_{net} = ma \qquad \leftarrow \textbf{1 mark}$$

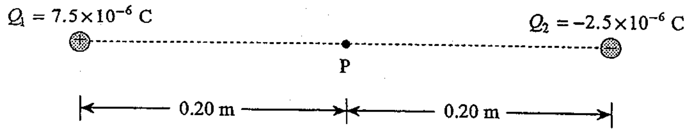
$$F_T - F_g = ma$$

$$F_T - mg = ma \qquad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$F_T - 87.5(3.61) = 87.5(1.20) \qquad \leftarrow \textbf{1 mark}$$

$$F_T = 421\text{ N} \qquad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

5. Electric charges are arranged as shown in the diagram below.

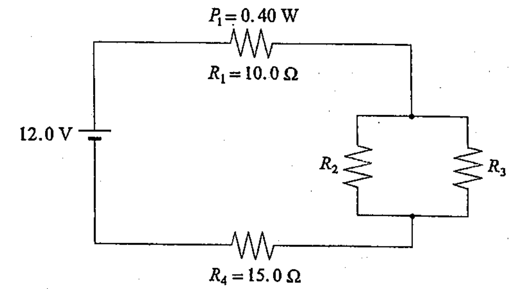


What is the electric field (magnitude and direction) at point P midway between the charges?

(7 marks)

$$E_1 = \frac{kQ_1}{r_1^2}$$
$$= \frac{9.0\times10^9 \cdot 7.5\times10^{-6}}{(0.20)^2}$$
$$= 1.69\times10^6 \text{ N/C (right)} \qquad \leftarrow 1\tfrac{1}{2} \textbf{ marks}$$
$$E_2 = \frac{kQ_2}{r_2^2}$$
$$= \frac{9.0\times10^9 \cdot 2.5\times10^{-6}}{(0.20)^2}$$
$$= 5.63\times10^5 \text{ N/C (right)} \qquad \leftarrow 1\tfrac{1}{2} \textbf{ marks}$$
$$E_T = E_1 + E_2 \qquad \leftarrow 2 \textbf{ marks}$$
$$= 1.69\times10^6 \text{ N/C} + 5.63\times10^5 \text{ N/C}$$
$$= 2.25\times10^6 \text{ N/C (right)}$$
$$= 2.3\times10^6 \text{ N/C (right)} \qquad \leftarrow 2 \textbf{ marks}$$

6. In the circuit below, resistor R_1 dissipates 0.40 W. Resistors R_2 and R_3 are identical.



What is the resistance of R_2?

(7 marks)

Key:

$$\left.\begin{aligned} P &= I^2R \\ P_1 &= I^2R_1 \\ I &= \left(\frac{P_1}{R_1}\right)^{\frac{1}{2}} \\ &= \left(\frac{0.40}{10}\right)^{\frac{1}{2}} \\ &= 0.20 \text{ A} \end{aligned}\right\} \leftarrow 2 \textbf{ marks}$$

$$\left.\begin{aligned} V_1 &= IR \\ &= 0.2(10) \\ &= 2 \text{ V} \end{aligned}\right\} \leftarrow 1 \textbf{ mark}$$

$$\left.\begin{aligned} V_4 &= IR \\ &= 0.2(15) \\ &= 3 \text{ V} \end{aligned}\right\} \leftarrow 1 \textbf{ mark}$$

$$\left.\begin{aligned} V_3 &= V_4 = 12 - V_1 - V_4 \\ &= 7 \text{ V} \end{aligned}\right\} \leftarrow 1 \textbf{ mark}$$

$$I_2 = I_3 \qquad \leftarrow 1 \textbf{ mark}$$

$$\left.\begin{aligned} V_3 &= I_3R_3 \\ 7 &= 0.1\ R_2 \\ R_2 &= 70\ \Omega \end{aligned}\right\} \leftarrow 1 \textbf{ mark}$$

Alternate Key:

$P = I^2 \cdot R$

$P_1 = I^2 \cdot R_1$

$\therefore I = \left(\frac{P_1}{R_1}\right)^{\frac{1}{2}}$

$= \left(\frac{0.40}{10.0}\right)^{\frac{1}{2}}$

$= 0.20\ \text{A}$ $\leftarrow$ **2 marks**

$\therefore R_{circuit} = \frac{V}{I}$

$= \frac{12.0}{0.20}$

$= 60.0\ \Omega$ $\leftarrow$ **2 marks**

$\therefore R_{\parallel} = 60.0\ \Omega - (10.0\ \Omega + 15.0\ \Omega)$

$= 35.0\ \Omega$ $\leftarrow$ **2 marks**

$\therefore R_2 = R_3 = 2 \cdot 35.0\ \Omega$

$= 70.0\ \Omega$ $\leftarrow$ **1 mark**

7. a) A proton moves with a speed of 3.6×10^5 m/s at right angles to a uniform 5.0×10^{-5} T magnetic field. What is the radius of curvature for the motion of the proton? **(5 marks)**

$F_c = \frac{mv^2}{R}$ $\leftarrow$ **1 mark**

$F_B = qvB$ $\leftarrow$ **1 mark**

$F_c = F_B$ $\leftarrow$ **1 mark**

$R = \frac{mv}{Bq} = \frac{(1.67 \times 10^{-27})(3.6 \times 10^5)}{(5.0 \times 10^{-5})(1.6 \times 10^{-19})}$ $\leftarrow$ **1 mark**

$R = 75\ \text{m}$ $\leftarrow$ **1 mark**

b) Describe the path of the proton in the magnetic field and use principles of physics to explain the proton's motion. **(4 marks)**

The path is circular. $\leftarrow$ **1 mark** ,

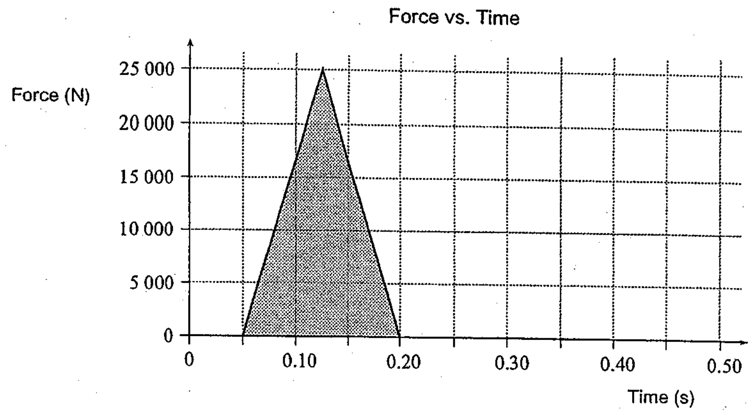
Moving charge in magnetic field produces a magnetic force. $\leftarrow$ **1 mark**

Force $\perp$ velocity. $\leftarrow$ **1 mark**

This perpendicular force (acting on proton) produces circular motion. $\leftarrow$ **1 mark**

20

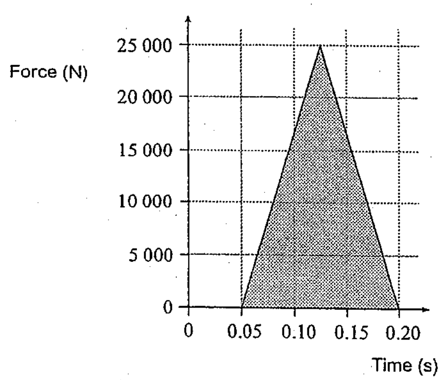
8. During a motor vehicle accident an unbelted passenger experienced a force which varied with time as shown on the graph.



a) Calculate the area of the shaded region in the graph. **(1 mark)**

two triangles: $(0.075 \times 25\ 000) = 1\ 875\ \text{N}\cdot\text{s}$

$= 1\ 900\ \text{N}\cdot\text{s}$ ← **1 mark**



b) What does this area represent? **(2 marks)**

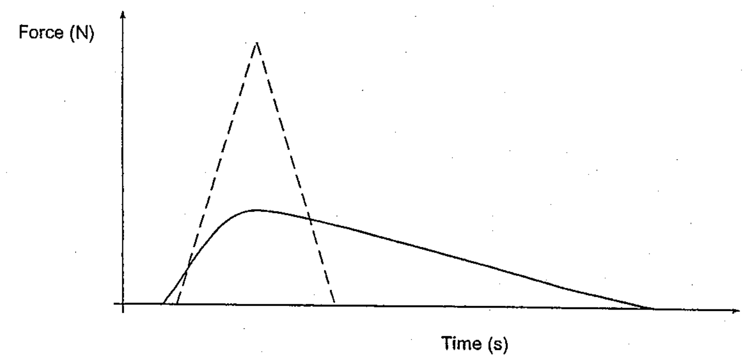
Impulse or change in momentum

c) If the passenger was wearing a seatbelt properly, the maximum force would have been one third the force experienced without the seatbelt. Sketch on the graph below how the force on the belted passenger might have varied with time. **(2 marks)**

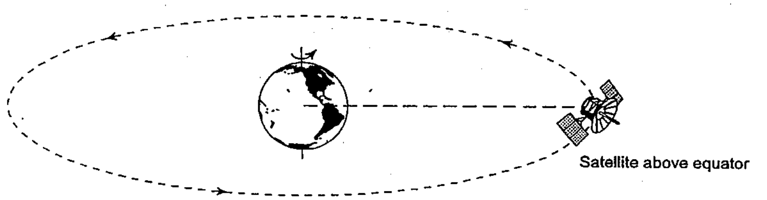
peak $= \frac{1}{3}(25\ 000) = 8\ 000\ \text{N}$ ← **1 mark**

(but for a longer period of time)

area should be (about) the same ← **1 mark**



9. Geostationary satellites appear to remain stationary to an observer on Earth. Such satellites are placed in orbit far above the equator.



Using principles of physics, explain why such satellites all have the same orbital radius. **(4 marks)**

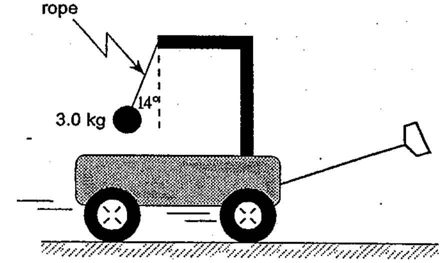
The period of such satellites must be 24 hours to remain stationary over one point. ← 1 mark
The centripetal force is a gravitational force. ← 2 marks
For a period of 24 hours there is one orbital radius. ← 1 mark

END OF KEY

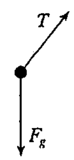
JUNE 2001
WRITTEN RESPONSE

ANSWER KEY

1. A 3.0 kg mass hangs at one end of a rope that is attached to a support on a child's wagon as shown in the diagram. The wagon is pulled to the right. (You may ignore air resistance.)

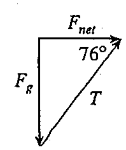


a) Draw and label a free body diagram showing the forces acting on the mass. **(2 marks)**



1 mark for each force ($\frac{1}{2}$ for labelling, $\frac{1}{2}$ for direction drawn correctly)

b) What is the acceleration of the wagon? **(3 marks)**



$$\tan 76° = \frac{F_g}{F_{net}}$$

$$F_{net} = \frac{F_g}{\tan 76°} = \frac{3.0 \times 9.8}{\tan 76°} = 7.33\text{ N}$$ **← 2 marks**

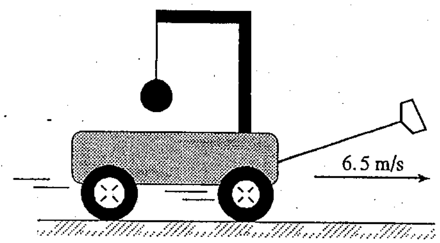
$$a = \frac{F_{net}}{m}$$

$$a = \frac{7.33}{3.0}$$

$$a = 2.4\text{ m/s}^2$$ **← 1 mark**

26

c) On the diagram below, sketch the position of the mass when the cart reaches a constant velocity of 6.5 m/s. **(1 mark)**



d) Using principles of physics, explain why the mass will be in this position. **(3 marks)**

Constant velocity means acceleration = 0 (**1 mark**)

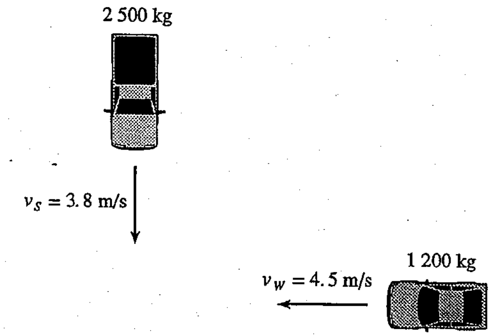
$\therefore F_{net} = 0$ (**1 mark**)

$\therefore$ Sum of all vertical forces is zero

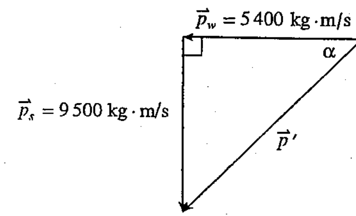
$\therefore$ Tension $= F_g$ (**$\frac{1}{2}$ mark**)

$\therefore$ There is no horizontal force component, so the mass hangs straight down. (**$\frac{1}{2}$ mark**)

2. Sally is driving south in her 2 500 kg pickup truck at 3.8 m/s when she collides with Willy driving west in his 1 200 kg car at 4.5 m/s.



The two vehicles lock together and slide over the wet parking lot. Find the speed and direction of the damaged vehicles immediately after the collision. **(7 marks)**



← **1 mark for momentums**

$(p')^2 = 5\,400^2 + 9\,500^2$ ← **1 mark for addition**

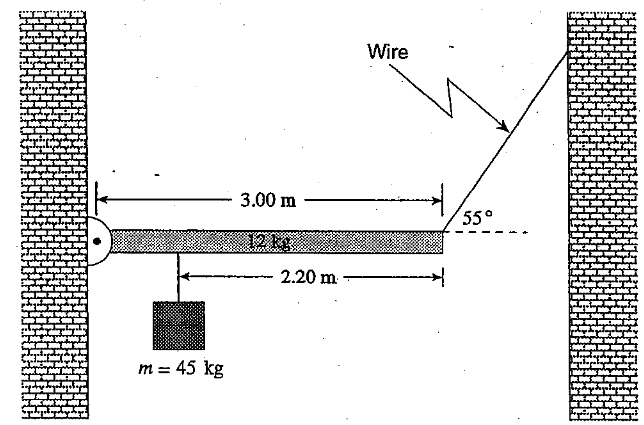
$p' = 10\,900$ kg·m/s ← **2 marks for pythagorus**

$v' = \dfrac{10\,900}{(2\,500 + 1\,200)} = 3.0$ m/s ← **1 mark for dividing by 3700**

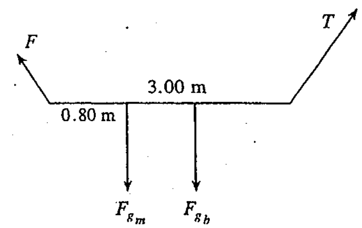
$\left.\begin{array}{l}\tan\alpha = \dfrac{9\,500}{5\,400} \\ \alpha = 60°\end{array}\right\}$ ← **1 mark**

$v' = 3.0$ m/s, 60° S of W ← **1 mark**

3. A uniform 12 kg beam of length 3.00 m holding a 45 kg mass is attached by a wire to a wall as shown.



What is the tension in the wire? **(7 marks)**



$$\tau_{cc} = \tau_c \qquad \leftarrow \textbf{1 mark}$$

$$\overbrace{(T \times \sin 55°) \times 3.00}^{\textbf{2 marks}} = \overbrace{((12 \times 9.8) \times 1.5)}^{\textbf{2 marks}} + \overbrace{(45 \times 9.8 \times 0.80)}^{\textbf{1 mark}} \qquad \leftarrow \textbf{5 marks}$$

$$T \times 2.457 = 176.4 + 352.8$$

$$T = \frac{529.2}{2.457} \qquad \leftarrow \textbf{1 mark}$$

$$T = 215 \text{ N}$$

204

4. An 884 kg satellite in orbit around a planet has a gravitational potential energy of -5.44×10^{10} J.

The orbital radius of the satellite is 8.52×10^{6} m and its speed is 7.84×10^{3} m/s.

a) What is the mass of the planet? **(3 marks)**

$$E_p = -\frac{GMm}{r} \quad \leftarrow \textbf{1 mark}$$

$$-5.44\times10^{10} = -\frac{6.67\times10^{-11}\times M\times 884}{8.52\times10^{6}} \quad \leftarrow 1\tfrac{1}{2}\textbf{ mark}$$

$$M = 7.86\times10^{24}\text{ kg} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

b) What is the kinetic energy of the satellite? **(2 marks)**

$$E_k = \frac{1}{2}mv^2 \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= \frac{1}{2}(884)(7.84\times10^{3})^2 \quad \leftarrow \textbf{1 mark}$$

$$= 2.72\times10^{10}\text{ J} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

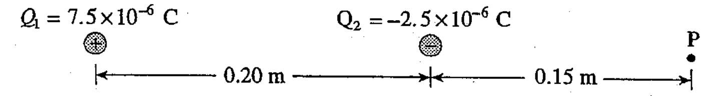
c) What is the total energy of the satellite? **(2 marks)**

$$E_T = E_k + E_p \quad \leftarrow \textbf{1 mark}$$

$$= 2.72\times10^{10} + (-5.44\times10^{10}) \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= -2.72\times10^{10}\text{ J} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

5. Electric charges Q_1 and Q_2 are arranged as shown in the diagram below.



What is the electric potential at point P? **(7 marks)**

$$V_1 = \frac{kQ_1}{r_1}$$

$$= \frac{9.0\times10^{9}\cdot 7.5\times10^{-6}}{(0.20\text{ m}+0.15\text{ m})}$$

$$= 1.93\times10^{5}\text{ V} \quad \leftarrow \textbf{2 marks}$$

$$V_2 = \frac{kQ_2}{r_2}$$

$$= \frac{(9.0\times10^{9})(-2.5\times10^{-6}\text{ C})}{(0.15\text{ m})}$$

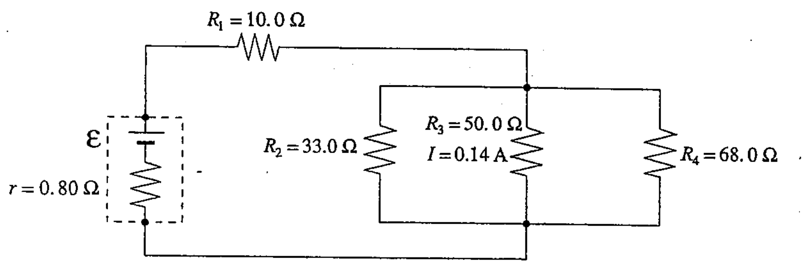
$$= -1.50\times10^{5}\text{ V} \quad \leftarrow \textbf{2 marks}$$

$$V_p = V_1 + V_2$$

$$= 1.93\times10^{5}\text{ V} + -1.50\times10^{5}\text{ V} \quad \leftarrow \textbf{2 marks}$$

$$= 4.3\times10^{4}\text{ V} \quad \leftarrow \textbf{1 mark}$$

6. The current through the $50.0\ \Omega$ resistor in the circuit below is 0.14 A.



a) Determine the emf of the battery. **(5 marks)**

$V_{\parallel} = I \cdot R$

$= I_3 \cdot R_3$

$= 0.14 \cdot 50.0$

$= 7.0$ V ← **1 mark**

$\therefore I_2 = \dfrac{V_{\parallel}}{R_2}$

$= \dfrac{7.0}{33.0}$

$= 0.21$ A ← **½ mark**

$I_4 = \dfrac{V_{\parallel}}{R_4}$

$= \dfrac{7.0}{68.0}$

$= 0.10$ A ← **½ mark**

$\therefore I_{\parallel} = I_2 + I_3 + I_4$

$= 0.21 + 0.14 + 0.10$

$= 0.45$ A ← **1 mark**

$R_{\parallel} = \dfrac{1}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$

$= 15.4\ \Omega$ ← **½ mark**

$R_T = R_1 + R_{\parallel} + r$

$= 10.0 + 15.4 + 0.80$

$= 26.2\ \Omega$ ← **½ mark**

$\therefore \mathcal{E} = I \cdot R_T$

$= 0.45 \cdot 26.2$

$= 11.9$ V

$= 12$ V ← **1 mark**

b) Determine the power dissipated in the battery's internal resistance. **(2 marks)**

$P_r = I^2 \cdot r$ ← **1 mark**

$= (0.45)^2 \cdot 0.80$

$= 0.16$ W ← **1 mark**

20

7. Protons travelling at 2.2×10^5 m/s enter at right angles to a magnetic field. The field is produced by a 0.16 m long solenoid. A current of 5.3 A flows through the 820 turns of wire of the solenoid.

a) What is the magnetic field in the solenoid? **(3 marks)**

$B = \mu_0 \frac{N}{\ell} I$ $\leftarrow$ **1 mark**

$B = \frac{(4\pi \times 10^{-7})(820)(5.3)}{(0.16)}$ $\leftarrow$ **1 mark**

$B = 3.4 \times 10^{-2}$ T $\leftarrow$ **1 mark**

b) What is the radius of curvature of the proton beam in the magnetic field of the solenoid? **(4 marks)**

$F_c = \frac{mv^2}{r}$ $\leftarrow \frac{1}{2}$ **mark**

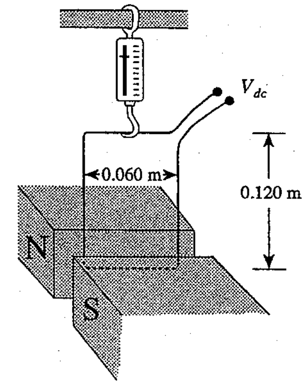
$F_E = Bqv$ $\leftarrow \frac{1}{2}$ **mark**

$$\left.\begin{aligned} Bqv &= \frac{mv^2}{r} \\ r &= \frac{mv}{Bq} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

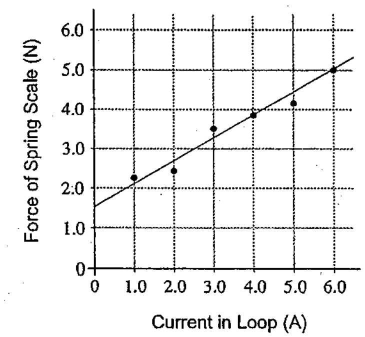
$r = \frac{(1.67 \times 10^{-27})(2.2 \times 10^5)}{(3.4 \times 10^{-2})(1.6 \times 10^{-19})}$ $\leftarrow$ **1 mark**

$r = 6.8 \times 10^{-2}$ m $\leftarrow$ **1 mark**

8. A rectangular loop is suspended by a spring scale between magnetic poles. The loop is 0.60 m wide by 0.120 m high.



As the current in the loop is varied, the readings of the spring scale and current are plotted on a graph.



a) What is the weight, in newtons, of the loop? **(1 mark)**

≈ 1.5 N

b) What is the slope of the best fit line? **(2 marks)**

drawing a reasonable line through y-axis and to, or beyond, last point **(1 mark)**

$\frac{\Delta F}{\Delta I} \approx 0.58\ \frac{\text{N}}{\text{A}}$ or $0.58\ \text{T}\cdot\text{m}$ **(1 mark)**

c) What is the magnitude of the magnetic field? **(2 marks)**

Since the best fit line is described by

$F_{scale} = F_{mag} + F_g$

$F_{scale} = B\ell(I) + F_g$

the slope equals $B\ell$ $\leftarrow$ **1 mark**

$\therefore 0.58 = B(0.060)$ $\leftarrow \frac{1}{2}$ **mark**

$B = 9.7\ \text{T}$ $\leftarrow \frac{1}{2}$ **mark**

9. A student decides to investigate how electric field varies along the line connecting two positive point charges. Charge Q_2 is greater than charge Q_1.

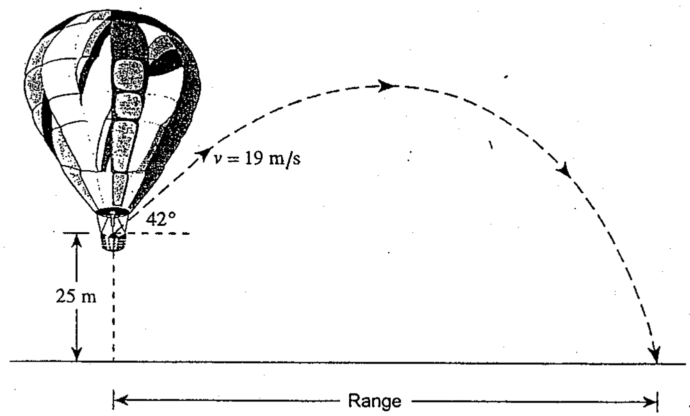
Using principles of physics, describe the electric field along the line from Q_1 to Q_2. **(4 marks)**

The electric field initially points to the right and decreases as you move along the line.
At one point, closer to Q_1, the electric field will be zero.
Past this point, the field is pointing to the left and increases.

END OF KEY

AUGUST 2001 ANSWER KEY
WRITTEN RESPONSE

1. A 0.50 kg ball is thrown at 42° above the horizontal at 19 m/s from a stationary hot air balloon 25 m above the ground.



What is the range? **(7 marks)**

$v_x = 19 \times \cos 42° = 14.1$ m/s
$v_y = 19 \times \sin 42° = 12.7$ m/s ← **1 mark**

$t_{up} = -\dfrac{v_y}{g} = -\dfrac{12.7}{-9.8} = 1.297$ s ← **1 mark**

$d_{up} = \frac{1}{2}at^2 = \frac{1}{2}9.8(1.297)^2$

$= 8.25$ m ← **1 mark**

$d_t = 25 + 8.25 = 33.25$ m ← **$\frac{1}{2}$ mark**

$t_d = \sqrt{\dfrac{2 \times d_t}{a}} = \sqrt{\dfrac{2 \times 33.25}{9.8}} = 2.60$ s ← **1 mark**

$t_t = t_{up} + t_d = 1.297 + 2.60 = 3.90$ s ← **$\frac{1}{2}$ mark**

$d_x = v_x \times t = 14.1 \times 3.90 = 55$ m (Range) ← **2 marks**

2. A rocket motor, capable of generating a 24 N · s impulse, is attached to a stationary frictionless 3.0 kg cart. The rocket motor is ignited.

a) What will the velocity of the cart be immediately after the rocket motor burns out? **(3 marks)**

Impulse $= m\Delta v$ ← **1 mark**

$24 = 3.0\Delta v \quad \therefore \Delta v = 8.0$ m/s
The final velocity of the 3.0 kg cart is 8.0 m/s. ← **2 marks**

b) What is the resulting kinetic energy of the cart? **(2 marks)**

$E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \cdot 3.0 \cdot (8.0)^2$ ← **1 mark**

$= 96$ J ← **1 mark**

c) A frictionless cart of larger mass will end up with less kinetic energy when powered by an identical rocket motor. Using principles of physics, explain this result. **(4 marks)**

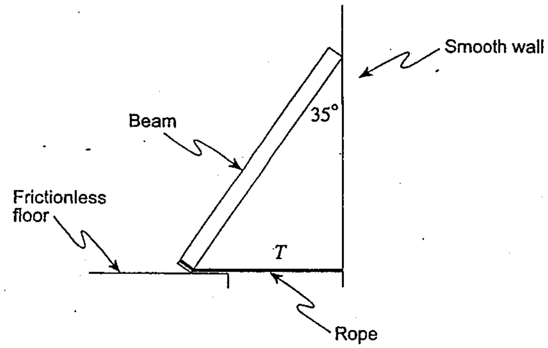
2 marks → {Work is done on both carts. However, the lighter cart is travelling faster while the force is being applied
2 marks → and therefore more work is being done on it while it travels the greater distance.

OR

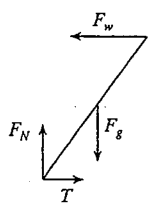
2 marks → {The velocity change of each cart is inversely related to its mass. The heavier cart therefore has a smaller velocity change.
2 marks → The v^2 term will therefore dominate in the final kinetic energy.

20

3. A 24 kg beam of length 2.4 m leans against a smooth wall. A horizontal rope tied to the wall and the beam holds the beam on a frictionless floor as shown.



a) Draw a labelled free-body diagram for the forces acting on the beam. **(2 marks)**



b) What is the tension in the rope? **(5 marks)**

$$\tau_{cc} = \tau_c \qquad \leftarrow \textbf{1 mark}$$

$$F_w \times \sin 55° \times 2.4 = mg \times \sin 35° \times 1.2 \qquad \leftarrow \textbf{2 marks}$$

$$F_w = \frac{24 \times 9.8 \times \sin 35° \times 1.2}{\sin 55° \times 2.4} \qquad \leftarrow \textbf{1 mark}$$

$$\therefore T = F_w = 82 \text{ N} \qquad \leftarrow \textbf{1 mark}$$

4. A spacecraft of mass 470 kg rests on the surface of an asteroid of radius 1 400 m and mass 2.0×10^{12} kg. How much energy must be expended so that the spacecraft may rise to a height of 2 800 m above the surface of the asteroid? **(7 marks)**

$$\Delta E = E_p' - E_p \qquad \leftarrow \textbf{2 marks}$$

$$= \left(-G\frac{Mm}{r'}\right) - \left(-\frac{GMm}{r}\right) \qquad \leftarrow \textbf{2 marks}$$

$$= \left(-\frac{6.67 \times 10^{-11} \times 2.0 \times 10^{12} \times 470}{(1\,400 + 2\,800)}\right) - \left(-\frac{6.67 \times 10^{-11} \times 2.0 \times 10^{12} \times 470}{1\,400}\right) \qquad \leftarrow \textbf{2 marks}$$

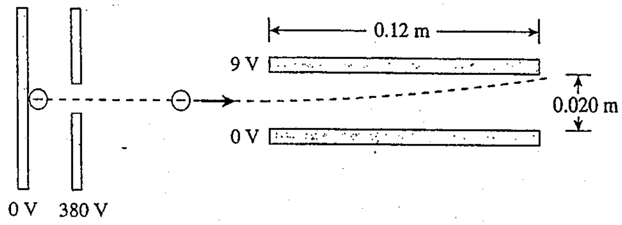
$$= (-14.9) - (-44.8)$$

$$= 29.9 \text{ J}$$

$$= 30 \text{ J} \qquad \leftarrow \textbf{1 mark}$$

21

5. A beam of electrons is directed to a region between oppositely charged parallel plates as shown in the diagram below.



a) The electron beam is produced by accelerating electrons through an electric potential difference of 380 V. What is the speed of the electrons as they leave the 380 V plate? **(3 marks)**

$$\Delta E_k = \Delta E_p$$

$$\frac{1}{2}mv^2 = QV_a$$

$$\therefore v = \left(\frac{2QV}{m}\right)^{\frac{1}{2}}$$

$$= \left(\frac{2 \cdot 1.6\times10^{-19} \cdot 380}{9.11\times10^{-31}}\right)^{\frac{1}{2}}$$

$$= 1.2\times10^{7} \text{ m/s} \quad \leftarrow \textbf{3 marks}$$

b) What is the electrostatic force on electrons in the region between the horizontal plates when they are connected to a 9.0 V potential difference? **(4 marks)**

$$E_{plates} = \frac{V}{d}$$

$$= \frac{9.0}{0.020}$$

$$= 4.5\times10^{2} \text{ V/m} \quad \leftarrow \textbf{2 marks}$$

$$\therefore F_E = qE$$

$$= 1.6\times10^{-19} \cdot 4.50\times10^{2} \quad \leftarrow \textbf{2 marks}$$

$$= 7.2\times10^{-17} \text{ N}$$

6. A 12 V battery transfers 33 C of charge to an external circuit in 7.5 s.

a) What current flows through the circuit? **(2 marks)**

$$I = \frac{q}{t} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= \frac{33\text{ C}}{7.5\text{ s}} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= 4.4\text{ A} \quad \leftarrow \textbf{1 mark}$$

b) What is the resistance of the circuit? **(2 marks)**

$$R = \frac{V}{I} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= \frac{12}{4.4} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= 2.7\,\Omega \quad \leftarrow \textbf{1 mark}$$

c) What is the power output of the battery? **(2 marks)**

$$P = V \cdot I \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= 12(4.4) \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$= 53\text{ W} \quad \leftarrow \textbf{1 mark}$$

d) The external circuit is most likely to consist of

- [x] a bulb.
- [ ] a kettle.
- [ ] a calculator.

(Check one response.) **(1 mark)**

2

7. An electron travelling at 7.7×10^{6} m/s enters at right angles into a uniform magnetic field. Inside the field the path of the electron has a radius of 3.5×10^{-2} m.

a) What is the magnitude of the magnetic field? **(4 marks)**

$$\left.\begin{aligned} F_C &= F_B \\ \frac{mv^2}{r} &= Bqv \\ B &= \frac{mv}{qR} \\ &= \frac{(9.11\times10^{-31})(7.7\times10^{6})}{(1.6\times10^{-19})(3.5\times10^{-2})} \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

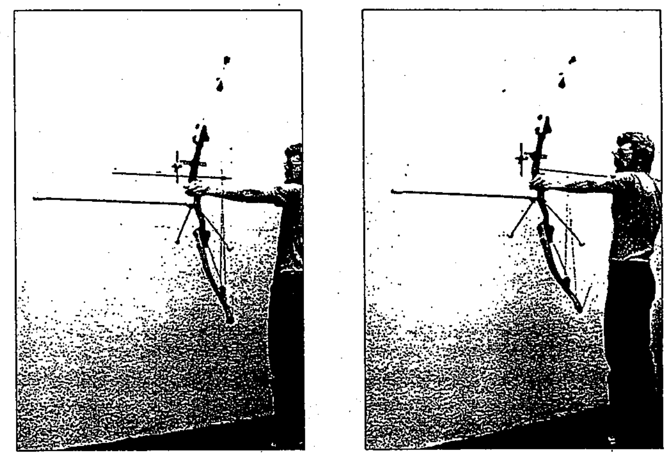
$$B = 1.3\times10^{-3}\ \text{T} \qquad \leftarrow \textbf{1 mark}$$

b) If the magnetic field is produced at the centre of a solenoid by a current of 0.62 A, what is the number of turns per unit length of the solenoid? **(3 marks)**

$$\left.\begin{aligned} B &= \mu_0 \frac{N}{\ell} I \\ \frac{N}{\ell} &= \frac{B}{\mu_0 I} \\ &= \frac{1.3\times10^{-3}}{(4\pi\times10^{-7})(0.62)} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

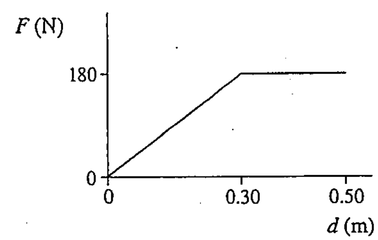
$$\frac{N}{\ell} = 1.6\times10^{3}\ \text{turns/m} \qquad \leftarrow \textbf{1 mark}$$

8. As a compound bow was drawn back, the applied forces and displacements were recorded.



F(N)	0	31	65	84	122	160	186	180	175	184	180
d(m)	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50

a) Plot a force vs. displacement graph below. **(2 marks)**



21

b) How much energy was stored in this compound bow?	(3 marks)

$Energy = W = area$

$27 + 36 \approx 63\ \text{J}$

9. Two identical light bulbs, wired in parallel to a battery, are equally bright. When one of the bulbs burns out, however, the other bulb is observed to glow brighter. Using principles of physics, explain why the battery causes the remaining bulb to glow more brightly.	(4 marks)

When one of two bulbs, wired in parallel to a battery, burns out, the resistance of the circuit increases. ← 1 mark

This results in a smaller current being delivered by the battery. ← 1 mark

The internal resistance of the battery causes the terminal voltage to increase, because $V_T = \mathcal{E} - Ir$. ← 1 mark

The bulb will now dissipate more power, because $P = \frac{V^2}{R}$. ← 1 mark (not in isolation)

If the number of paths for current is reduced to one, the current increases in the remaining path. ← 1 mark

← Any 4 for 4 marks

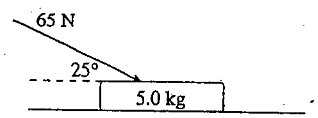
END OF KEY

21

JANUARY 2002
WRITTEN RESPONSE

ANSWER KEY

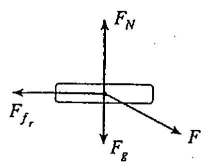
1. A 65 N force is applied to a 5.0 kg object as shown.



$\mu = 0.25$

The coefficient of friction between the object and the horizontal surface is 0.25.

a) Draw and label a free body diagram showing the forces acting on the object. **(2 marks)**



← **2 marks**

b) What is the acceleration of the object? **(5 marks)**

$a = \frac{F_{net}}{m}$ ← **1 mark**

$F_{net} = F_x - F_{f_r}$ ← **1 mark**

$= F_x - \mu F_N$

$= F\cos 25 - \mu(F_g + F_y)$ ← **2 marks**

$= F\cos 25 - \mu(F_g + F\sin 25)$

$= 65 \cdot \cos 25 - 0.25(5.0 \cdot 9.8 + 65 \cdot \sin 25)$

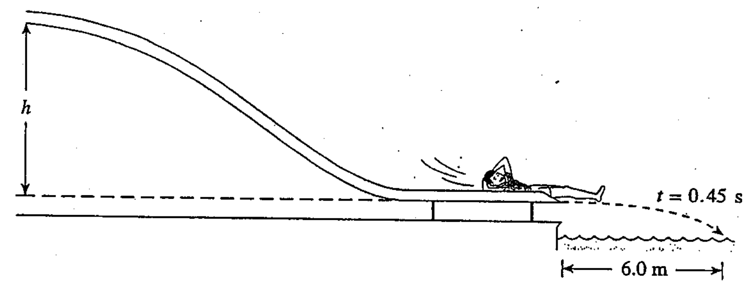
$= 58.9 - 19.1$

$= 39.8$ N

$\therefore a = \frac{39.8}{5.0}$

$= 8.0\ \text{m/s}^2$ ← **1 mark**

2. A water slide is made so that swimmers, starting from rest at the top, leave the end of the slide travelling horizontally as shown.



One person is observed to hit the water at a horizontal distance of 6.0 m from the end of the slide 0.45 s after leaving the slide. Ignore friction and air resistance.

a) From what vertical height, h, did the person start? **(5 marks)**

$v = \frac{d}{t} = \frac{6.0}{0.45} = 13.3$ m/s ← **1 mark**

$E_k = E_p$ ← **1 mark**

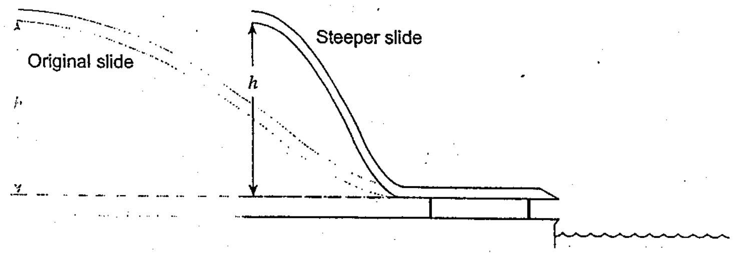
$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$ ← **2 marks**

$h = \frac{v^2}{2g}$

$= \frac{13.3^2}{2 \times 9.8}$

$= 9.1$ m ← **1 mark**

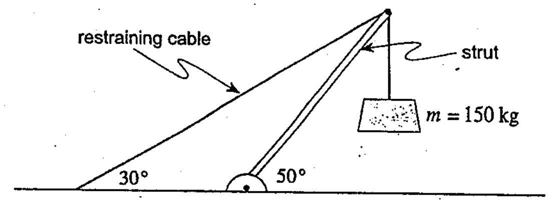
b) Another slide has the same vertical height, h, as the original slide, but has a much steeper slide angle.



The same person is observed to go down this steep slide. Using principles of physics, explain how the new horizontal distance from the edge of the slide compares with the first situation. The effects of friction and air resistance are negligible. (4 marks)

The person should hit the water at the same distance (1 mark) as before since the vertical height is the same in each case. The horizontal velocity (1 mark) will be the same $(E_p = E_k)$ and hence the person will follow the same path as before and land in the water at the same distance. (2 marks)

3. The crane shown in the diagram below is made up of a strut and a restraining cable. The strut is uniform in cross section with a length of 6.0 m and a mass of 85 kg.



What is the tension in the restraining cable while the crane is supporting a 150 kg load? (7 marks)

$\Sigma\tau_{pivot} = 0$

or $\Sigma\tau_{ccw} = \Sigma\tau_{cw}$ ← **1 mark**

$T\sin 20 \cdot \cancel{l} = W\sin 40 \cdot \cancel{l} + F_g \sin 40 \cdot \frac{\cancel{l}}{2}$ ← **3 marks**

$\therefore T = \dfrac{W\sin 40 + \frac{F_g \sin 40}{2}}{\sin 20}$ ← **1 mark**

$= \dfrac{150 \cdot 9.8 \cdot \sin 40 + \frac{85 \cdot 9.8 \cdot \sin 40}{2}}{\sin 20}$ ← **1 mark**

$= \dfrac{945 + 268}{\sin 20}$

$= 3\,545$ N

$= 3.5 \times 10^3$ N ← **1 mark**

4. What minimum energy is required to take a stationary 3.5×10^{3} kg satellite from the surface of the Earth and put it into a circular orbit with a radius of 6.88×10^{6} m and an orbital speed of 7.61×10^{3} m/s? (Ignore Earth's rotation.) **(7 marks)**

$$E_{orbit}=\frac{1}{2}E_p$$
$$=\frac{1}{2}\left(-\frac{GmM}{R}\right)$$
$$=\frac{1}{2}\left(-\frac{6.67\times10^{-11}(3.5\times10^{3})(5.98\times10^{24})}{6.88\times10^{6}}\right)$$
$$=-1.01\times10^{11}\text{ J}$$ ← **4 marks**

$$E_{surface}=-\frac{GmM}{R}$$
$$=-\frac{6.67\times10^{-11}(3.5\times10^{3})(5.98\times10^{24})}{6.38\times10^{6}}$$
$$=-2.19\times10^{11}\text{ J}$$ ← **1 mark**

$$\Delta E=E_{orbit}-E_{surface}$$ ← **1 mark**
$$=(-1.01\times10^{11})-(-2.19\times10^{11})$$
$$=1.17\times10^{11}\text{ J}$$
$$=1.2\times10^{11}\text{ J}$$ ← **1 mark**

5. A 12 V battery from a car is used to operate a 65 W headlight.

a) How much energy does the headlight use in 1.5 hours? **(2 marks)**

$E=P\times t$ ← $\frac{1}{2}$ **mark**

$=65\times1.5\times3600$ ← **1 mark**

$=3.5\times10^{5}$ J ← $\frac{1}{2}$ **mark**

b) What total charge passes through the headlight during this time? **(3 marks)**

$Q=\frac{\Delta E}{V}$ ← $\frac{1}{2}$ **mark**

$=\frac{3.5\times10^{5}\text{ J}}{12\text{ V}}$ ← **2 marks**

$=29\ 000$ C ← $\frac{1}{2}$ **mark**

OR

$Q=It$ ← $\frac{1}{2}$ **mark**

$=(5.42\text{ A})(5\ 400\text{ s})$ ← **2 marks**

$=29\ 000$ C ← $\frac{1}{2}$ **mark**

c) What is the total number of electrons that pass through the headlight during this time period? **(2 marks)**

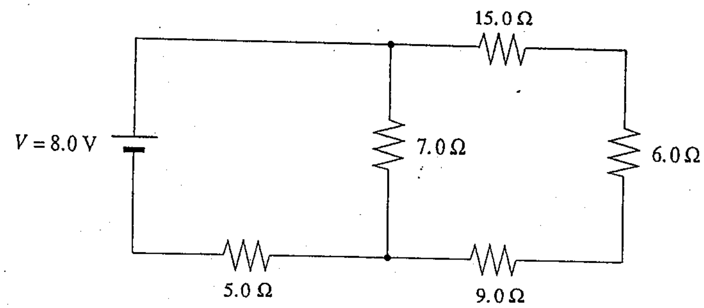
$N=\frac{Q}{e}$ ← **1 mark**

$=\frac{29\ 000}{1.6\times10^{-19}\text{ C}}$ ← **1 mark**

$=1.8\times10^{23}$ electrons

21

6. What is the potential difference across the $6.0\ \Omega$ resistor in the circuit shown? **(7 marks)**



$R_{P_1} = 15.0\ \Omega + 6.0\ \Omega + 9.0\ \Omega$

$= 30.0\ \Omega$ ← **1 mark**

$\frac{1}{R_p} = \frac{1}{7.0} + \frac{1}{30.0}$

$R_p = 5.68$ ← **1 mark**

$R_T = 5.0 + 5.68$

$= 10.68$ ← **1 mark**

$I_T = \frac{V_T}{R_T} = \frac{8.0}{10.68} = 0.75$ ← **1 mark**

$V_p = V_T - V_5$

$= 8.0\ \text{V} - 0.75 \times 5.0$

$= 4.25$ ← **1 mark**

$I_p = \frac{V_p}{R_p} = \frac{4.25}{30.0} = 0.142$ ← **1 mark**

$V_6 = I_p R$

$= 0.142 \times 6.0$

$= 0.85\ \text{V}$ ← **1 mark**

7. A proton travelling at 2200 m/s enters a 0.15 T magnetic field perpendicularly.

a) What is the magnitude of the proton's acceleration while travelling through the magnetic field? **(4 marks)**

$F_B = QvB$ ← **1 mark**

$F = ma$ ← **1 mark**

$a = \frac{QvB}{m}$ ← **1 mark**

$= \frac{(1.6\times10^{9})(2200)(15)}{1.67\times10^{-27}}\ \text{m/s}^2$ ← **½ mark**

$= 3.2\times10^{10}\ \text{m/s}^2$ ← **½ mark**

b) What is the radius of the proton's circular path while travelling through the magnetic field? **(3 marks)**

$a = \frac{v^2}{r}$ ← **1 mark**

$r = \frac{v^2}{a}$ ← **1 mark**

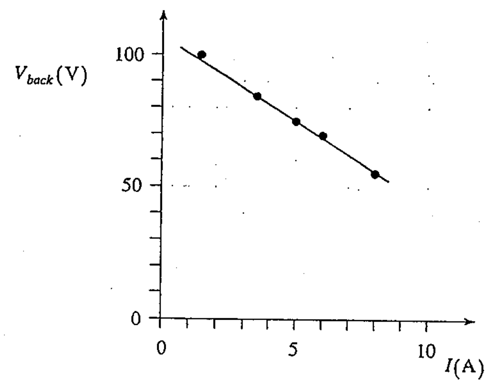
$= \frac{(2200)^2}{3.2\times10^{10}}\ \text{m}$ ← **½ mark**

$= 1.5\times10^{-4}\ \text{m}$ ← **½ mark**

8. A constant voltage is applied to an electric motor being used to lift a series of masses onto a truck. The current through the motor and its back emf are recorded for each different load. This data is shown below.

I(A)	V_{back}(V)
1.5	98
3.5	84
5.0	76
6.0	70
8.0	54

a) Plot the data on the graph below and draw the best fit straight line. **(2 marks)**



- **plot 5 points: 1 mark**
- **draw best fit line: 1 mark**

b) Determine the magnitude of the slope of the line. **(1 mark)**

magnitude of slope ≈ 6.3 V/A(Ω)

$$slope = \frac{\Delta V}{\Delta I} = \frac{54-84}{8-3.5} \qquad \leftarrow \tfrac{1}{2} \text{ mark}$$

$$= \frac{-30}{4.5}$$

$$= -6.67\,\frac{\text{V}}{\text{A}}(\Omega)(\text{positive value ok}) \qquad \leftarrow \tfrac{1}{2} \text{ mark}$$

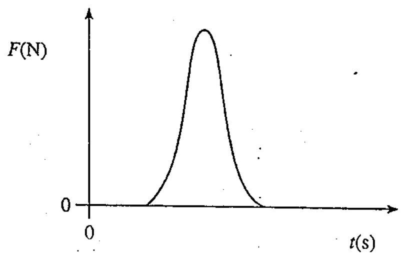
c) What does the magnitude of the slope of this line represent? **(2 marks)**

resistance (or internal resistance ok) ← 2 marks

"decreasing resistance": –1
"change in resistance": –1
"emf + / – resistance": $-1\frac{1}{2}$

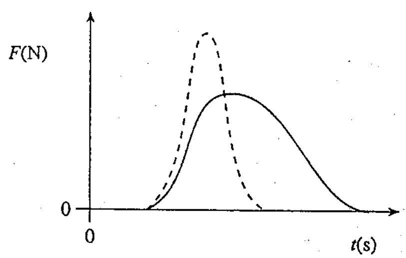
21

9. In sports such as golf, tennis and baseball, a player exerts a force over a time interval on a ball in order to give it a high speed, as shown on the graph.



Players are instructed to "follow through" on their swing. A weaker player may not exert as large a force but may give the ball a higher speed than a stronger player.

a) Sketch on the graph below how a weaker player can overcome the force handicap. **(1 mark)**

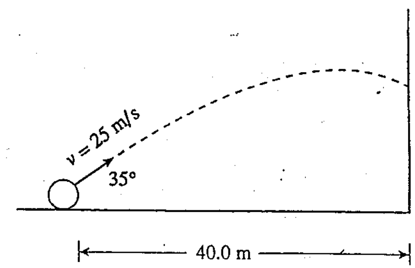


b) Explain how the player can impart a greater impulse on a ball. **(3 marks)**

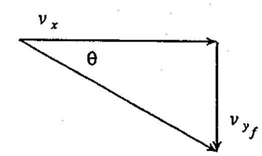
By exerting a smaller force for a longer time, the weaker player may be able to deliver a greater impulse to the ball.

END OF KEY

1. A projectile is launched towards a wall as shown in the diagram below.



With what velocity (magnitude and direction) does the projectile hit the wall? **(7 marks)**



$d_x = v_x \cdot t$

$v_x = v \cdot \cos 35$

$= 25 \cdot \cos 35$ ← **1 mark**

$= 20.5$ m/s

$\therefore t = \dfrac{d_x}{v_x}$

$= \dfrac{40.0}{25 \cdot \cos 35}$

$= 1.95$ s ← **1 mark**

$v_{y_f} = v_{y_i} + at$

$= 25 \cdot \sin 35 + (-9.8 \cdot 1.95)$ ← **1 mark**

$= -4.77$ m/s ← **1 mark**

$\therefore v^2 = v_x^2 + v_{y_f}^2$

$= (20.5)^2 + (-4.77)^2$

$\therefore v = 21$ m/s ← **1 mark**

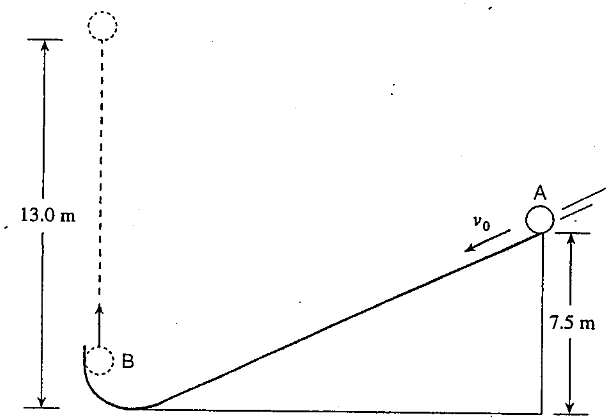
$\theta = \tan^{-1}\left(\dfrac{v_{y_f}}{v_x}\right)$

$= \tan^{-1}\left(\dfrac{4.77}{20.5}\right)$

$= 13°$ ← **2 marks**

2. A 0.50 kg ball starting from position A which is 7.5 m above the ground, is projected down an incline as shown. Friction produces 10.7 J of heat energy.

The ball leaves the incline at position B travelling straight upward and reaches a height of 13.0 m above the floor before falling back down.



What was the initial speed, v_0, at position A? Ignore air resistance. **(7 marks)**

$$E_{T_A} = E_{Total} \qquad \leftarrow \textbf{2 marks}$$

$$E_{K_A} + E_{P_A} = E_{P_{top}} + E_h$$

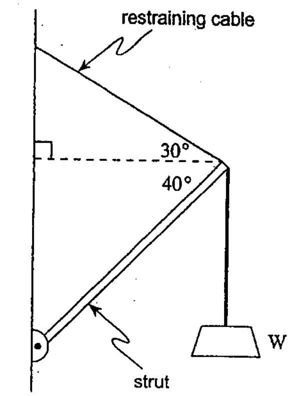
$$\frac{1}{2}mv^2 + mgh_A = mgh + E_h \qquad \leftarrow \textbf{2 marks}$$

$$\frac{1}{2}\times 0.50\left(v^2\right) + 0.50\times 9.8\times 7.5 = 0.50\times 9.8\times 13\times + 10.7 \qquad \leftarrow \textbf{1 mark}$$

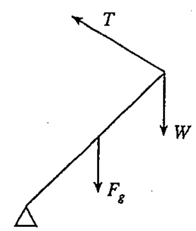
$$v^2 = \frac{74.4 - 36.75}{0.25} \qquad \leftarrow \textbf{1 mark}$$

$$v = 12 \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

3. The crane assembly shown in the diagram below consists of a uniform 4.0 m long 65 kg strut and a restraining cable.



What is the maximum weight W that can be supported by this crane if the maximum tension that the restraining cable can withstand is 2400 N? The vertical rope is strong enough to support any required load. **(7 marks)**



$$\Sigma\tau_{pivot} = 0$$

or $\Sigma\tau_{cw} = \Sigma\tau_{ccw}$ $\quad \Big\}\ \frac{1}{2}$ **mark**

$$W\sin 50\cdot\cancel{4} + F_g\cdot\sin 50\cdot\frac{\cancel{4}}{2} = T\sin 70\cdot\cancel{4} \qquad \leftarrow \textbf{4}\tfrac{1}{2}\ \textbf{marks}$$

$$\therefore W = \frac{T\sin 70 - \frac{F_g\sin 50}{2}}{\sin 50}$$

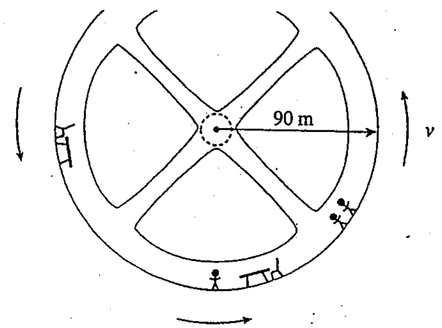
$$= \frac{2\,400\sin 70 - \frac{65\cdot 9.8\cdot\sin 50}{2}}{\sin 50} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{2\,255 - 244}{\sin 50}$$

$$= 2\,626 \text{ N}$$

$$= 2.6\times 10^3 \text{ N} \qquad \leftarrow \textbf{1 mark}$$

22



a) What is the period of the space station's rotation so that a 70 kg astronaut will experience a normal force by the outer wall equal to 60% of his weight on the surface of the earth? **(5 marks)**

$F_{net} = ma_c$ ← **1 mark**

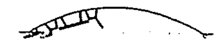
$$\left.\begin{aligned} 0.60\,mg &= m\frac{4\pi^2}{T^2}R \\ T^2 &= \frac{4\pi^2(90)}{0.60(9.8)} \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

$T = 25\text{ s}$ ← **1 mark**

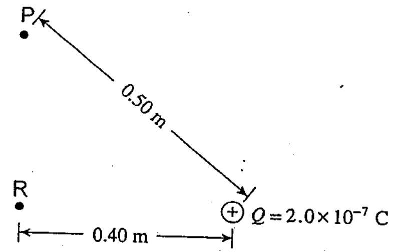
b) What would be the effect experienced by the astronaut if the space station rotated faster so that the period of rotation was decreased? Explain your predicted effect. **(4 marks)**

The period is decreased and therefore the centripetal force increases ($F_c \propto \frac{1}{T^2}$). Since the centripetal force is only provided by the normal force, the normal force on the astronaut increases (F_N is perceived as weight.)

4. A space station of radius 90 m is rotating to simulate a gravitational field.



5. What is the electric potential difference between points P and R due to the fixed point charge Q? **(7 marks)**



$$V_P = \frac{kQ}{R_1}$$

$$= \left(\frac{9.00 \times 10^9 \cdot 2.0 \times 10^{-7}}{0.50}\right) \quad \leftarrow \textbf{2 marks}$$

$$= 3\,600 \text{ V}$$

$$V_R = \frac{kQ}{R_2}$$

$$= \left(\frac{9.00 \times 10^9 \cdot 2.0 \times 10^{-7}}{0.40}\right) \quad \leftarrow \textbf{2 marks}$$

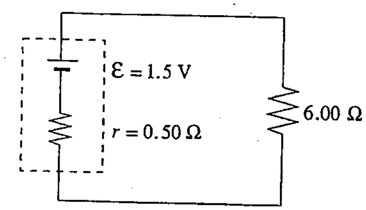
$$= 4\,500 \text{ V}$$

$$\therefore \Delta V_{PR} = V_P - V_R = 4\,500 - 3\,600 \quad \leftarrow \textbf{2 marks}$$

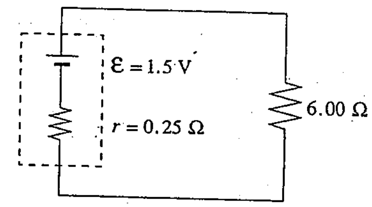
$$= \pm 900 \text{ V} \quad \leftarrow \textbf{1 mark}$$

6. Each of the two cells shown is connected to an external 6.00 Ω resistor.

Cell A



Cell B



With supporting calculations, state which cell delivers the greater power to the 6.00 Ω resistor. **(7 marks)**

Cell A:

$$I = \frac{\mathcal{E}}{6.00 + r} \quad \leftarrow \textbf{1 mark}$$

$$I = \frac{1.5}{6.50}$$

$$= 0.23 \quad \leftarrow \textbf{1 mark}$$

$$P_L = I^2 R$$

$$= 0.23^2 \times 6.00$$

$$= 0.32 \text{ W} \quad \leftarrow \textbf{1 mark}$$

Cell B:

$$I = \frac{\mathcal{E}}{6.00 + r} \quad \leftarrow \textbf{1 mark}$$

$$I = \frac{1.5}{6.25}$$

$$= 0.24 \quad \leftarrow \textbf{1 mark}$$

$$P_L = I^2 R$$

$$= 0.24^2 \times 6.00$$

$$= 0.35 \text{ W} \quad \leftarrow \textbf{1 mark}$$

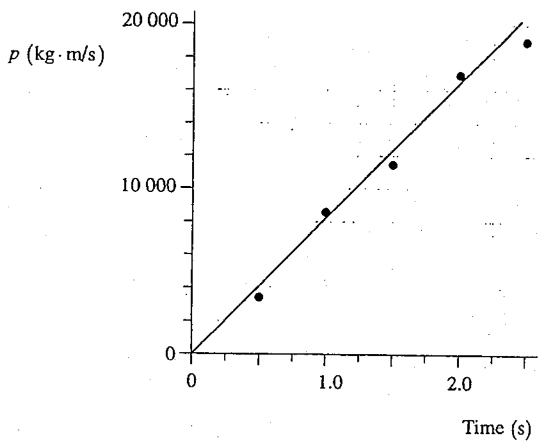
Therefore, cell B delivers more power. ← 1 mark

Note: Sig figs were ignored, since answer is not numerical. Also, units were ignored for the same reason.

8. As a formula one race car accelerates uniformly from rest, its momentum is recorded at regular time intervals. This data is shown below.

Time (s)	p(kg · m/s)
0.50	3 800
1.0	8 300
1.5	11 500
2.0	16 800
2.5	19 000

a) Plot the data on the graph below and draw the best fit straight line. **(2 marks)**



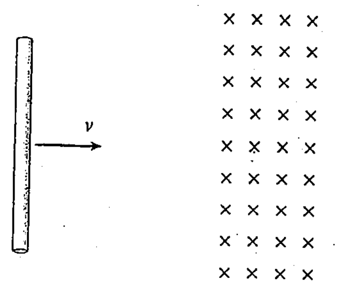
b) Determine the slope of the line (include units). **(1 mark)**

slope ≈ 8 000 kg · m/s^2 or 8 000 N

c) What does the slope of this line represent? **(2 marks)**

the net force on the car

9. A steel rod passes through a region where a magnetic field exists.



The rod slows as it passes through the magnetic field. Using principles of physics, explain why this happens. **(4 marks)**

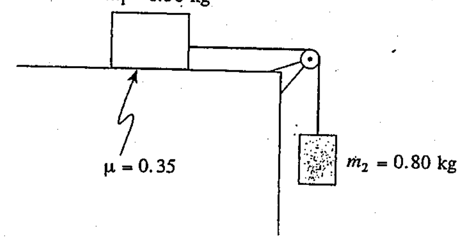
As the rod passes through the magnetic field the free charges within it experience a magnetic force. ← 1 mark This force moves the charges along the rod . ← 1 mark As the charges begin to move along the rod they experience another magnetic force. ← 1 mark This second force is directed against the motion of the rod . ← 1 mark

END OF KEY

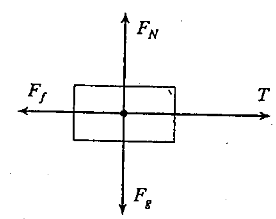
AUGUST 2002
WRITTEN RESPONSE

ANSWER KEY

1. Two masses are connected by a light string passing across a frictionless pulley as shown in the diagram below. The coefficient of friction between mass m_1 and the horizontal surface is 0.35.



a) Draw and label a free body diagram showing the forces acting on mass m_1. **(2 marks)**



← 2 marks

220

b) What is the tension in the connecting string? **(5 marks)**

$$T - F_f = m_1 a$$

$$F_{2g} - T = m_2 a$$

Combining:

$$a = \frac{F_{2g} - F_f}{m_1 + m_2} \quad \leftarrow \textbf{2 marks}$$

$$= \frac{m_2 g - \mu m_1 g}{m_1 + m_2}$$

$$= \frac{0.80 \cdot 9.8 - 0.35 \cdot 1.50 \cdot 9.8}{1.50 + 0.80}$$

$$= 1.2 \text{ m/s}^2 \quad \leftarrow \textbf{1 mark}$$

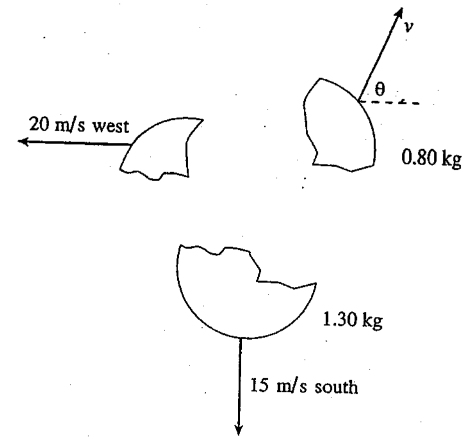
Substituting:

$$T = m_1 a + F_f$$

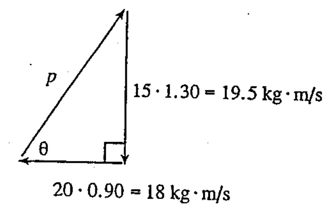
$$= 1.50 \cdot 1.2 + 0.35 \cdot 1.50 \cdot 9.8$$

$$= 6.9 \text{ N} \quad \leftarrow \textbf{2 marks}$$

2. A 3.00 kg object initially at rest explodes into three fragments as shown in the diagram below.



What are the speed and direction of the 0.80 kg fragment? **(7 marks)**



← **3 marks**

$$p^2 = 18^2 + 19.5^2$$

$$p = 26.5 \text{ kg} \cdot \text{m/s} \quad \leftarrow \textbf{1 mark}$$

$$v = \frac{p}{m}$$

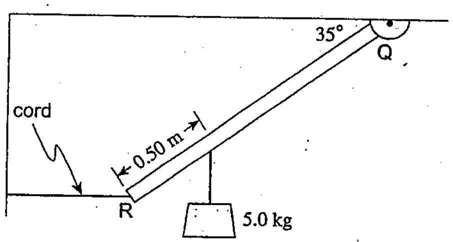
$$= \frac{26.5}{0.80}$$

$$= 33 \text{ m/s} \quad \leftarrow \textbf{1 mark}$$

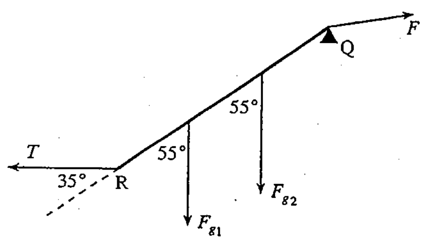
$$\theta = \tan^{-1}\left(\frac{19.5}{18}\right)$$

$$= 47° \quad \leftarrow \textbf{2 marks}$$

3. A uniform 2.4 m beam RQ has a mass of 3.0 kg. The beam is hinged at Q and held in place by a horizontal cord attached at R. A 5.0 kg mass is suspended 0.50 m from R.



What is the tension in the horizontal cord? **(7 marks)**



$\Sigma\tau_Q = 0$

$\Sigma\tau_{cw_Q} = \Sigma\tau_{ccw_Q}$ ← $1\frac{1}{2}$ marks

$T\sin 35\cdot 2.4 = F_{g_1}\cdot \sin 55\cdot 1.9 + F_{g_2}\cdot \sin 55\cdot 1.2$

$T\sin 35\cdot 2.4 = 5.0\cdot 9.8\cdot \sin 55\cdot 1.9 + 3.0\cdot 9.8\cdot \sin 55\cdot 1.2$ ← $4\frac{1}{2}$ marks

$\therefore T = \dfrac{5.0\cdot 9.8\cdot \sin 55\cdot 1.9 + 3.0\cdot 9.8\cdot \sin 55\cdot 1.2}{\sin 35\cdot 2.4}$

$= 76\text{ N}$ ← 1 mark

4. A 720 kg communication satellite is in synchronous orbit around the planet Mars. This synchronous orbit matches the period of rotation so that the satellite appears to be stationary over a position on the equator of Mars. What is the orbital radius of this satellite? **(7 marks)**

Planetary Data for Mars	
Mass:	6.42×10^{23} kg
Period of rotation:	8.86×10^{4} s

$F_{net} = ma_c$

$F = \dfrac{GmM}{R^2}$ ← 1 mark

$F_g = \dfrac{m4\pi^2 R}{T^2}$ ← 1 mark

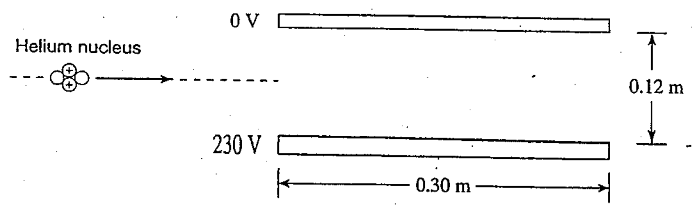
$\dfrac{GmM}{R^2} = \dfrac{m4\pi^2 R}{T^2}$ ← 2 marks

$R^3 = \dfrac{GMT^2}{4\pi^2}$

$R^3 = \dfrac{(6.67\times 10^{-11})(6.42\times 10^{23})(8.86\times 10^{4})^2}{4\pi^2}$ ← 2 marks

$R = 2.0\times 10^{7}\text{ m}$ ← 1 mark

5. A helium nucleus having twice the charge and four times the mass of a proton is travelling with high velocity when it enters a set of charged plates as shown.



a) Find the magnitude of the acceleration of the helium nucleus due to these plates. **(5 marks)**

$a = \frac{F}{m} \qquad F = qE \qquad E = \frac{V}{d}$

$a = \frac{qV}{md}$ ← **3 marks**

$= \frac{2 \times 1.6 \times 10^{-19} \times 230}{4 \times 1.67 \times 10^{-27} \times 0.12}$ ← **1 mark**

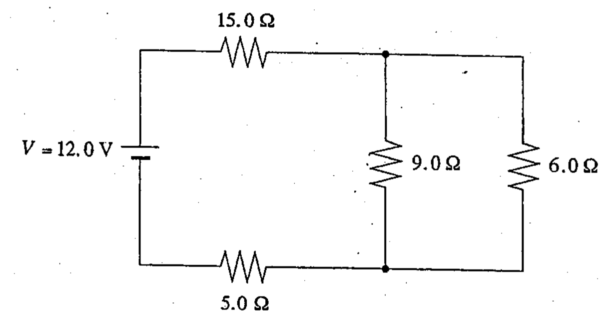
$= 9.2 \times 10^{10}\ \text{m/s}^2$ ← **1 mark**

b) A proton travelling at the same velocity as the helium nucleus is then sent through these same plates. Explain, using principles of physics, why the acceleration of the proton is larger than that of the helium nucleus. **(4 marks)**

A proton has one quarter of the mass and one half of the charge of a helium nucleus. ← **2 marks**

The proton will have twice the acceleration of the helium nucleus: $a \propto \frac{q}{m}$. ← **2 marks**

6. How much energy does the 6.0 Ω resistor dissipate in 15 seconds in the circuit shown? **(7 marks)**



$\frac{1}{R_p} = \frac{1}{9.0} + \frac{1}{6.0}$

$R_p = 3.6$ ← **1 mark**

$R_T = R_{15} + R_p + R_5$

$= 15.0 + 3.6 + 5.0$

$= 23.6\ \Omega$ ← **1 mark**

$I_T = \frac{V_T}{R_T} = \frac{12.0}{23.6}$

$= 0.508\ \text{A}$ ← **1 mark**

$V_p = V_T - V_{15} - V_5$

$= 12.0 - 0.51 \times 15.0 - 0.51 \times 5.0$

$= 1.83\ \text{V}$ ← **2 marks**

$I_6 = \frac{V_p}{R_6} = \frac{1.83}{6.0}$

$= 0.305\ \text{A}$ ← **1 mark**

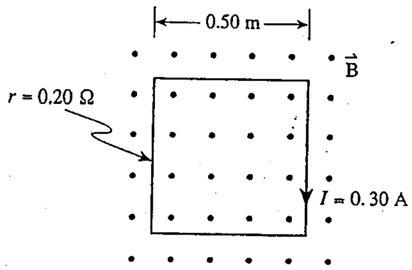
$E = VIt$

$= 1.83 \times 0.305 \times 15$

$= 8.4\ \text{J}$ ← **1 mark**

22

7. The single square loop of copper wire with a resistance of 0.20 Ω has a current of 0.30 A due to a continuously increasing magnetic field.



At what rate, in T/s, is the magnetic field increasing? **(7 marks)**

$\mathcal{E} = IR$

$\mathcal{E} = 0.30(0.20)$

$\mathcal{E} = 0.060 \text{ V}$ ← **2 marks**

$0.060 = \dfrac{0.50^2(B_f - B_i)}{\Delta t}$ ← **2 marks**

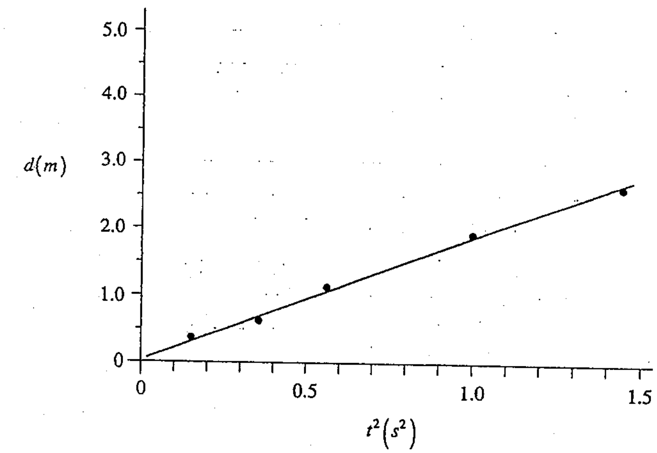
$0.060 = \dfrac{0.25(\Delta B)}{\Delta t}$ ← **1 mark**

$\dfrac{\Delta B}{\Delta t} = 0.24 \text{ T/s}$ ← **2 marks**

8. The first colonists on Mars conduct a physics experiment by dropping a small mass (from rest) and recording its displacement at regular time intervals. This data is shown below.

d (m)	t (s)	t^2 (s^2)
0.30	0.40	**0.16**
0.60	0.60	**0.36**
1.20	0.80	**0.64**
1.80	1.00	**1.00**
2.70	1.20	**1.44**

a) Plot a graph of displacement versus time squared and draw the best fit straight line. **(2 marks)**



228

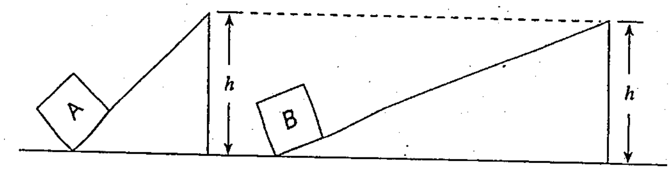
b) Determine the slope of the line. **(2 marks)**

slope ≅ 1.9 m/s^2

c) Based on this experiment, what is the acceleration due to gravity on Mars? **(1 mark)**

≅ 3.8 m/s^2

9. Identical blocks are placed on inclines as shown. The coefficients of friction between the blocks and the inclined surfaces are identical.



Both blocks are then pushed to the top of each incline at the same constant speed. Using principles of physics, explain which block required more work to reach the top of the incline. **(4 marks)**

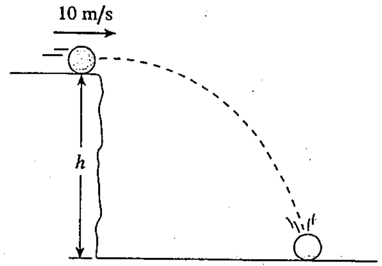
Work = Force × Distance (1 mark). To move either block up the ramp, friction must be overcome. In the case of block B, the force of friction is greater (1 mark) and the distance is longer (1 mark). Therefore more work is done moving block B to the top of the ramp (1 mark).

END OF KEY

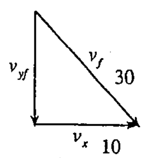
JANUARY 2003
WRITTEN RESPONSE

ANSWER KEY

1. A blue ball rolls off the cliff shown below at 10 m/s and hits the ground with a speed of 30 m/s.



a) What is the vertical component of the ball's impact velocity? **(4 marks)**



← **1 mark**

$v_{yf}^2 = v_f^2 - v_x^2$ ← **2 marks**

$v_{yf}^2 = 30^2 - 10^2$

$v_{yf} = -28.3$ m/s ← **$\frac{1}{2}$ mark for magnitude, $\frac{1}{2}$ mark for direction**

b) How high (h) is the cliff? **(3 marks)**

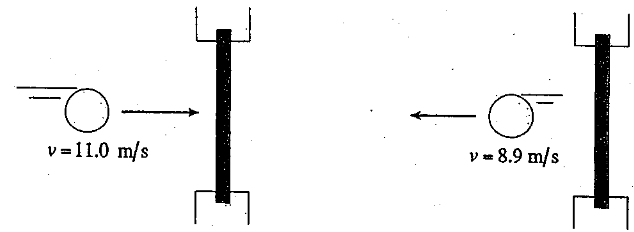
$v_{yf}^2 = v_{yi}^2 + 2(a_g)d_y$ ← **2 marks**

$-28.3^2 = 0^2 + 2(-9.8)d_y$

$d_y = -40.9$ m ← **1 mark**

$\therefore h = 41$ m

2. a) A 0.120 kg ball travelling at 11.0 m/s impacts a solid massive steel wall. The ball bounces straight back at 8.9 m/s.



If the ball was in contact with the steel wall for 0.17 s, what is the magnitude of the force that the steel wall imparted on the ball? **(5 marks)**

Impulse = change in momentum ← **1 mark**

$F \times t = m_2v_2 - m_1v_1$ ← **2 marks**

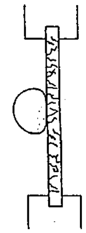
$F = \dfrac{m_2v_2 - m_1v_1}{t}$

$F = \dfrac{0.120\times(-8.9) - 0.120\times(11.0)}{0.17}$ ← **1 mark**

$F = \dfrac{-2.388}{0.17}$

$F = 14$ N ← **1 mark**

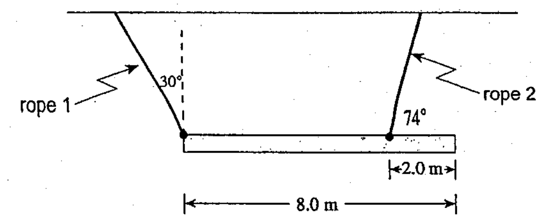
b) An identical ball with the same initial speed as in part a) is then thrown towards a glass window. The glass window cracks and the ball stops in 0.17 s.



Using principles of physics, explain which ball, from part a) or part b), experiences the greater force. **(4 marks)**

The force experienced is equal to the rate of change in momentum. ($\Delta p/\Delta t$) (1 mark)
Since both collisions occur in the same time the greater force is experienced by the ball experiencing the greater change in momentum. (2 marks)
The ball in part a) experienced a larger change in momentum as it changed direction. (1 mark)

3. The 8.0 m uniform beam shown below, suspended horizontally by two ropes, has a mass of 75 kg.



Determine the tension in rope 1 and the tension in rope 2. **(7 marks)**

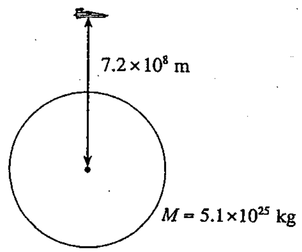
$$\Sigma\tau = 0 = -F_{T1}\cos 30°(6.0) + 75(9.8)(2.0)$$

$F_{T1} = 2.8\times10^2$ N ← **4 marks**

$$\Sigma F_y = 0 = -75(9.8) + 283\cos 30° + F_{T2}\sin 74°$$

$F_{T2} = 5.1\times10^2$ N ← **3 marks**

4. A 12 000 kg spaceship is 7.2×10^{8} m from the centre of a planet that has a mass of 5.1×10^{25} kg.



The spaceship gains 9.0×10^{11} J of kinetic energy as it falls to the planet's surface. What is the radius of this planet? **(7 marks)**

$$E_{p_1} = E_{p_2} + E_k \qquad \leftarrow \textbf{1 mark}$$

$$E_{p_2} = E_{p_1} - E_k$$

$$-\frac{GMm}{R_2} = -\frac{GMm}{R_1} - E_k \qquad \leftarrow \textbf{1 mark}$$

$$\frac{-6.67\times10^{-11}\times5.1\times10^{25}\times12\,000}{R_2} = \frac{-6.67\times10^{-11}\times5.1\times10^{25}\times12\,000}{7.2\times10^{8}} - 9.0\times10^{11} \qquad \leftarrow \textbf{3 marks}$$

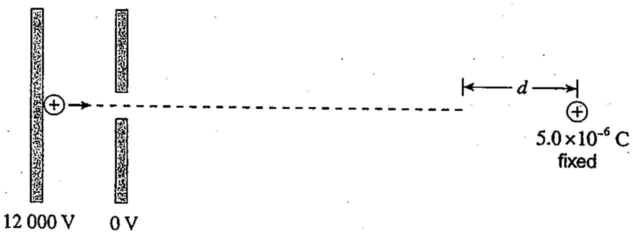
$$\frac{-4.082\times10^{19}}{R_2} = -5.6695\times10^{10} - 9.0\times10^{11}$$

$$\frac{-4.082\times10^{19}}{R_2} = -9.567\times10^{11} \qquad \leftarrow \textbf{1 mark}$$

$$\frac{-4.082\times10^{19}}{-9.567\times10^{11}} = R_2$$

$$4.3\times10^{7}\text{ m} = R_2 \qquad \leftarrow \textbf{1 mark}$$

5. A proton, accelerated from rest through a potential difference of 1.2×10^{4} V, is directed at a fixed 5.0×10^{-6} C charge.



(Diagram not to scale.)

a) What is the speed of the proton as it leaves the parallel plates? **(4 marks)**

$$E_k = \Delta E_p \qquad \leftarrow \textbf{1 mark}$$

$$\frac{1}{2}mv^2 = q\Delta V \qquad \leftarrow \textbf{1 mark}$$

$$v^2 = \frac{2q\Delta V}{m}$$

$$v^2 = \frac{2(1.6\times10^{-19})(12\,000)}{1.67\times10^{-27}} \qquad \leftarrow \textbf{1 mark}$$

$$v = 1.5\times10^{6}\text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

b) What is the distance d from the fixed charge when the proton is stopped? **(3 marks)**

$$\Delta E_p = \Delta E_p \qquad \leftarrow \textbf{1 mark}$$

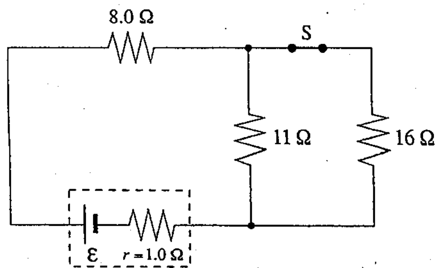
$$q\Delta V = \frac{kqQ}{R} \qquad \leftarrow \textbf{1 mark}$$

$$R = \frac{kQ}{\Delta V}$$

$$= \frac{(9.0\times10^{9})(5.0\times10^{-6})}{12\,000} \qquad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$R = 3.8\text{ m} \qquad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

6. The terminal voltage of the battery is 5.8 V.



a) What is the emf of this battery? **(6 marks)**

$\frac{1}{R_{\parallel}} = \frac{1}{11} + \frac{1}{16}$

$R_{\parallel} = 6.5\ \Omega$ ← **1 mark**

external $R_T = 6.5\ \Omega + 8.0\ \Omega$

external $R_T = 14.5\ \Omega$ ← **1 mark**

$I_t = \frac{V_t}{R_t}$ ← **1 mark**

$= \frac{5.8}{14.5}$

$I_t = 0.40$ A ← **1 mark**

$V = \mathcal{E} - Ir$ ← **1 mark**

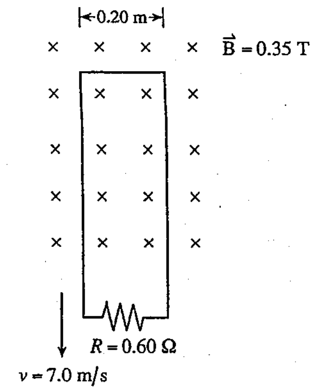
$5.8 = \mathcal{E} - 0.40(1.0)$ ← $\frac{1}{2}$ **mark**

$\mathcal{E} = 6.2$ V ← $\frac{1}{2}$ **mark**

b) What is the effect on the emf of the battery when switch S is opened? **(1 mark)**

no effect

7. A rectangular wire loop with a resistance of 0.60 Ω is pulled out of a magnetic field at 7.0 m/s as shown in the diagram.



a) What is the current in the loop? **(5 marks)**

$\mathcal{E} = B\ell v$

$\mathcal{E} = 0.35 \times 0.20 \times 7$

$\mathcal{E} = 0.49$ V

← $2\frac{1}{2}$ **marks**

$I = \frac{\mathcal{E}}{R}$

$= \frac{0.49}{0.60} = 0.82$ A **(1 mark)**

← $2\frac{1}{2}$ **marks**

b) What is the direction of the current in the loop? **(2 marks)**

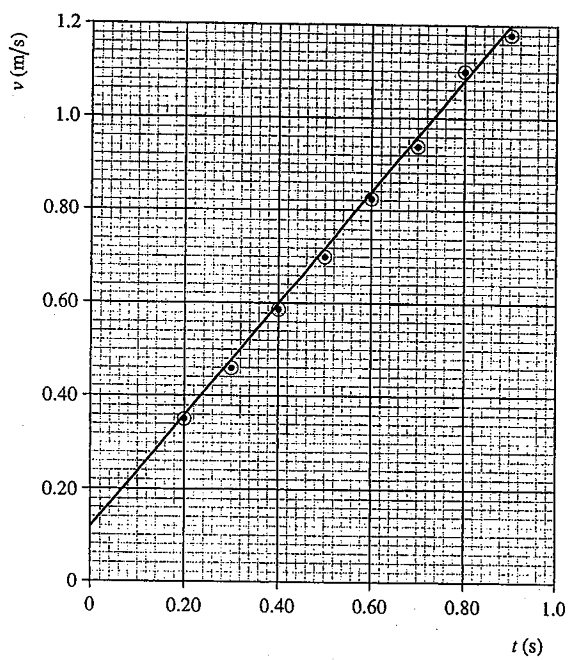
☑ clockwise

☐ counter-clockwise

8. The following data is collected in a kinematics experiment using a toy car.

t (s)	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
v (m/s)	0.35	0.46	0.59	0.70	0.83	0.94	1.10	1.18

a) Plot the data on a v vs. t graph and extrapolate your line back to $t = 0$. **(2 marks)**



b) What is the displacement of the toy car from $t = 0$ to $t = 0.90$ s? **(2 marks)**

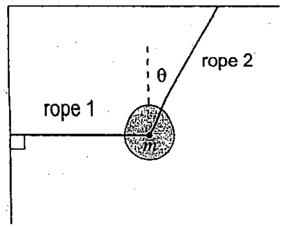
$$\Delta x \doteq \frac{1}{2}(0.12 + 1.20)(0.90 \text{ s})$$

$$\doteq 0.59 \text{ m}$$

c) What does the y-intercept of the graph represent? **(1 mark)**

initial speed of the car

9. A mass suspended by two ropes is shown below. It is noticed that for any angle θ used for rope 2, the tension in rope 2 is always greater than the tension in rope 1.



Using principles of physics, explain why this is the case. **(4 marks)**

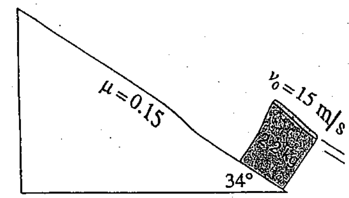
Rope 1 always has a tension equal to only the horizontal component of rope 2, whereas rope 2 (1 mark) also has a vertical component equal to the weight of the mass. (1 mark) These 2 conditions require the T_2 to be larger than T_1. (2 marks)

END OF KEY

JUNE 2003
WRITTEN RESPONSE

ANSWER KEY

1. A 2.2 kg can of paint is projected up an inclined plane with an initial velocity of 15 m/s as shown below.



a) Determine the magnitude of the force due to friction which acts on the paint can as it slides up the incline. **(2 marks)**

$F_{fr} = 0.15(2.2)\cdot 9.8\cdot\cos 34°$ ← **1 mark**

$F_{fr} = 2.68\ \text{N}$ ← **1 mark**

$\cong 2.7\ \text{N}$

b) Determine the magnitude of the net force on the paint can as it slides up the incline. **(3 marks)**

$F_{net} = F_{g_{\parallel}} + F_{fr}$

$F_{net} = 2.2(9.8)\cdot\sin 34° + 2.68$ ← **2 marks**

$F_{net} = 14.7\ \text{N}$ ← **1 mark**

$\cong 15\ \text{N}$

c) Determine how far the paint can slides up the incline before stopping. **(2 marks)**

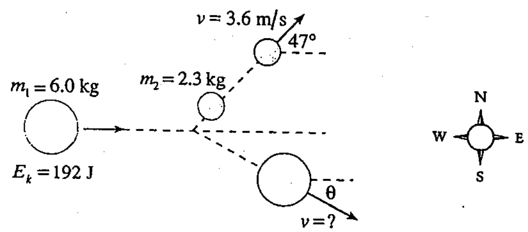
$v^2 = v_0^2 + 2ad$

$0^2 = 15^2 + 2\left(\frac{-14.7}{2.2}\right)\cdot d$ ← **1 mark**

$d = 16.8\ \text{m}$ ← **1 mark**

$\cong 17\ \text{m}$

2. A 6.0 kg ball having a kinetic energy of 192 J was travelling due east when it underwent an oblique collision with a stationary 2.3 kg ball. The 2.3 kg ball travelled at 3.6 m/s at an angle of 47° north of east after the collision.



(Diagram not to scale.)

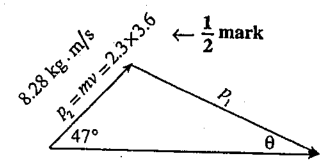
What was the velocity (magnitude and direction) of the 6.0 kg ball after the collision? **(7 marks)**

$$E_k = \frac{1}{2}mv^2$$

$$192\text{ J} = \frac{1}{2}\times 6.0\times v^2$$

$$\sqrt{\frac{2\times 192}{6.0}} = v$$

8.0 m s $= v$ ← **2 marks**



$p_b = mv$
$= 6.0\times 8.0$
$= 48$ kg·m/s ← $\frac{1}{2}$ **mark**

$$p_1^{\,2} = p_b^{\,2} + p_2^{\,2} - 2\times p_b\times p_2\times\cos\theta$$

$p_1 = \sqrt{48^2 + 8.28^2 - 2\times 48\times 8.28\times\cos 47°}$ ← **1 mark**

$p_1 = 42.8$ kg·m/s ← **1 mark**

$$v_1^{\,1} = \frac{p_1}{m} = \frac{42.8}{6.0}$$

$= 7.1$ m/s ← **1 mark**

$$\frac{\sin\theta}{8.28} = \frac{\sin 47°}{42.8}$$

$\theta = 8.1$ ← **1 mark**

$\therefore v = 7.1$ m/s at 8.1° S of E

OR

$$E_k = \frac{1}{2}mv^2$$

$$192\text{ J} = \frac{1}{2}\times 6.0\times v^2$$

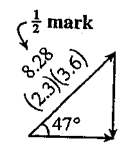
$$\sqrt{\frac{2\times 192}{6.0}} = v$$

8.0 m s $= v$ ← **2 marks**

Momentum is conserved ← **1 mark**

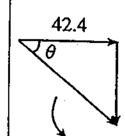
$P_x(\text{initial}) = (6)(8) = 48$

$P_x(\text{final}) = 48$ ← $\frac{1}{2}$ **mark**



$8.28\sin 47° = 6.06$

$8.28\cos 47° = 5.65$



$\sqrt{(42.4)^2 + (6.06)^2} = 42.8$ ← **1 mark**

$42.8 = 6\,v$

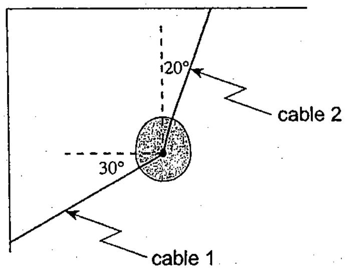
$v = 7.1$ m/s ← **1 mark**

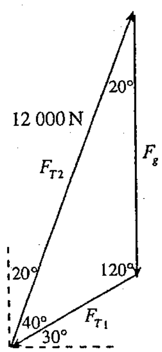
$$\tan\theta = \frac{6.06}{42.4}$$

$\underbrace{\theta = 8.14° \text{ S of E}}_{\text{1 mark}}$

23

3. A wrecking ball is suspended by two cables as shown below. If the tension in cable 2 is 12 000 N, what is the weight of the wrecking ball? **(7 marks)**





← **4 marks** for diagram

$$\frac{12\,000\text{ N}}{\sin 120°}=\frac{F_g}{\sin 40°} \quad \leftarrow \textbf{2 marks}$$

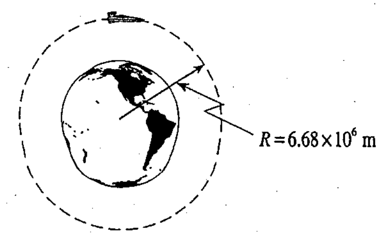
$$F_g = 8\,900\text{ N} \quad \leftarrow \textbf{1 mark}$$

OR

$$\left.\begin{aligned}
&\mathcal{E}F_x = 0\\
&T_{2_x} = 12\,000\sin 20°\\
&T_{2_x} = 4\,100\\
&T_{1_x} = T_{2_x} = 4\,100\\
&T_{1_y} = 4\,100\tan 30°\\
&T_{1_y} = 2\,370
\end{aligned}\right\} \leftarrow 3\tfrac{1}{2}\textbf{ marks}$$

$$\left.\begin{aligned}
&\mathcal{E}F_y = 0\\
&T_{2_y} = 12\,000\cos 20°\\
&T_{2_y} = 11\,300\\
&T_{1_y} + F_g = T_{2_y}\\
&F_g = 11\,300 - 2\,370\\
&F_g = 8\,900\text{ N}
\end{aligned}\right\} \leftarrow 3\tfrac{1}{2}\textbf{ marks}$$

4. A 3.2×10^4 kg spacecraft is in a circular orbit of radius 6.68×10^6 m around the earth.



a) Calculate the period of this spacecraft. **(5 marks)**

$$F_c = F_g \quad \leftarrow \textbf{1 mark}$$

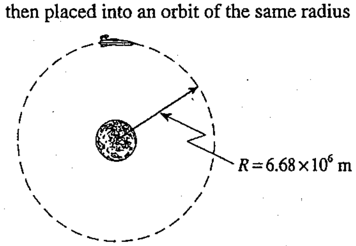
$$\frac{m4\pi^2R}{T^2}=\frac{GMm}{R^2} \quad \leftarrow \textbf{2 marks}$$

$$T=\sqrt{\frac{4\pi^2R^3}{GM}}$$

$$=\sqrt{\frac{4\times\pi^2\times\left(6.68\times10^6\right)^3}{6.67\times10^{-11}\times5.98\times10^{24}}} \quad \leftarrow \textbf{1 mark}$$

$$T = 5430\text{ s} \quad \cong 5400\text{ s} \quad \leftarrow \textbf{1 mark}$$

b) If this spacecraft is then placed into an orbit of the same radius around the moon,

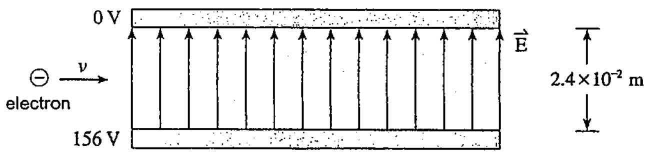


explain how and why the period of this spacecraft would be different than when it was orbiting the earth. **(4 marks)**

The moon has a smaller mass than that of the earth. This will produce longer periods around the moon when a satellite is placed at an equal orbital radius. $\left(T\propto\frac{1}{\sqrt{M}}\right)$ **(4 marks)**

OR The gravitational field strength is smaller which means that the centripetal acceleration is smaller. Therefore the spacecraft has to travel slower and therefore has a longer period. (4 marks)

5. Electrons with a speed of 3.3×10^7 m/s are directed between charged parallel plates as shown.



a) What are the magnitude and direction of the electrostatic force on the electron while it is between the plates? **(5 marks)**

$F = qE$ ← **1 mark**

$= q\left(\frac{V}{d}\right)$ ← **1 mark**

$= \left(1.6\times10^{-19}\text{ C}\right)\left(\frac{156\text{ V}}{2.4\times10^{-2}\text{ m}}\right)$ ← **1 mark**

$F = 1.04\times10^{-15}$ N ← **1 mark**

downward ← **1 mark**

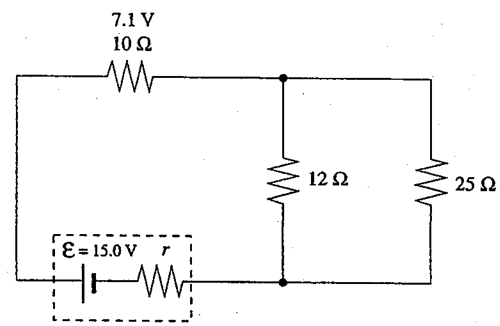
b) What is the magnitude of the acceleration of the electron while it is between the plates? **(2 marks)**

$a = \frac{F_{net}}{m}$

$= \frac{1.04\times10^{-15}\text{ N}}{9.11\times10^{-31}\text{ kg}}$

$a = 1.1\times10^{15}$ m/s^2 ← **2 marks**

6. The potential difference across the 10 Ω resistor is 7.1 V.



a) What is the power dissipated by the 25 Ω resistor? **(4 marks)**

$I = \frac{V}{R}$

$= \frac{7.1}{10}$

$I = 0.71$ A ← $\frac{1}{2}$ **mark**

$\frac{1}{R_{\parallel}} = \frac{1}{12} + \frac{1}{25}$

$R_{\parallel} = 8.1\ \Omega$ ← **1 mark**

$V_{\parallel} = IR_{\parallel}$

$= 0.71(8.1)$

$V_{\parallel} = 5.76$ V ← **1 mark**

$P_{25} = \frac{V^2}{R}$ ← $\frac{1}{2}$ **mark**

$= \frac{5.76^2}{25}$

$P_{25} = 1.3$ W ← **1 mark**

b) What is the internal resistance of the battery? **(3 marks)**

$$V_t = IR_{external}$$

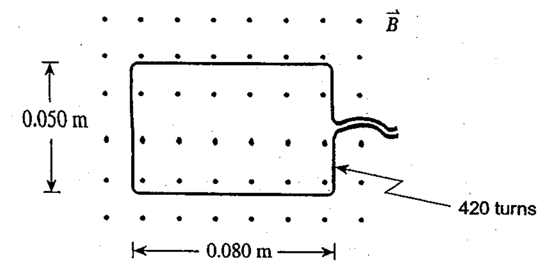
$$= 0.71(18.1) = 12.9 \text{ V} \quad \leftarrow \textbf{1 mark}$$

$$V = \mathcal{E} - I(r) \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$12.9 = 15.0 - 0.71r \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$r = 3.0\ \Omega \quad \leftarrow \textbf{1 mark}$$

7. A 420-turn rectangular coil is positioned as shown in a 0.14 T magnetic field.



The magnetic field strength is increased over a 0.20 s interval, inducing an average emf of 1.8 V in the coil. What is the final magnetic field strength? **(7 marks)**

$$\mathcal{E} = \frac{-N\Delta\Phi}{\Delta t} \quad \leftarrow \textbf{1 mark}$$

$$\Delta\Phi = \frac{\mathcal{E}\cdot\Delta t}{N}$$

$$\Delta B\cdot A = \frac{\mathcal{E}\cdot\Delta t}{N} \quad \leftarrow \textbf{1 mark}$$

$$\Delta B = \frac{\mathcal{E}\cdot\Delta t}{N\cdot A} \quad \leftarrow \textbf{1 mark}$$

$$= \frac{(1.8\cdot 0.20)}{420\cdot(0.050\cdot 0.080)} \quad \leftarrow \textbf{2 marks}$$

$$= 0.21 \text{ T}$$

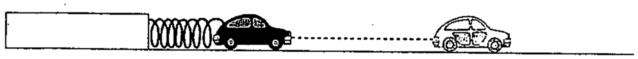
$$\therefore B_f - B_i = 0.21$$

$$\therefore B_f = 0.21 + B_i$$

$$= 0.21 + 0.14$$

$$= 0.35 \text{ T} \quad \leftarrow \textbf{2 marks}$$

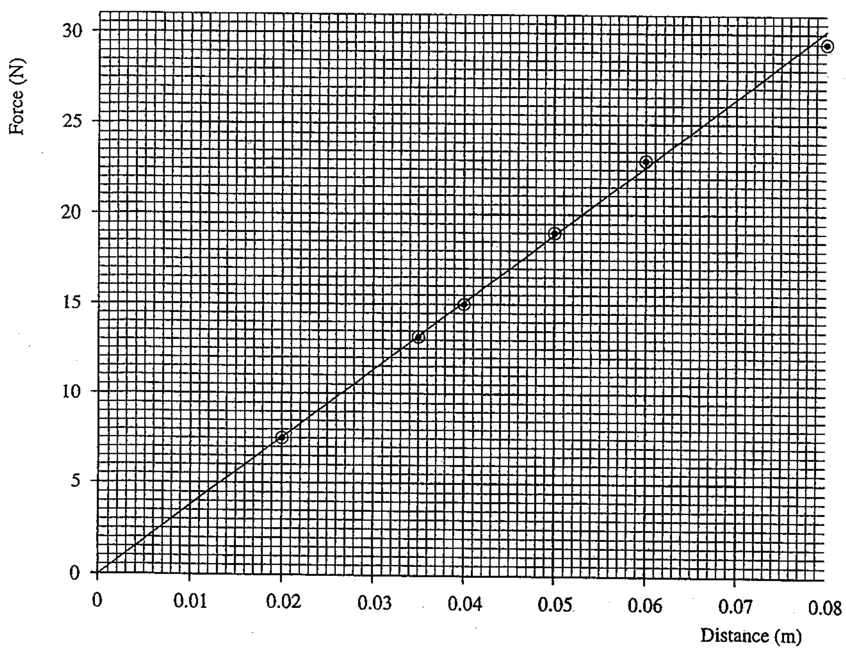
8. A small toy car is placed in a spring-loaded launcher.



The force needed to compress the spring is recorded as a function of distance.

a) Plot a graph of force vs. distance using the data table shown. **(2 marks)**

Force (N)	Distance (m)
7.5	0.020
13.2	0.035
14.8	0.040
19.1	0.050
23.0	0.060
29.5	0.080



b) Calculate the area under this graph from distance = 0.0 m to distance = 0.080 m. **(2 marks)**

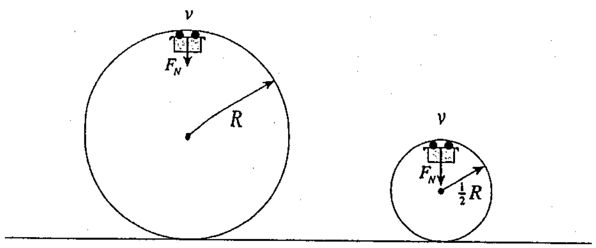
$$Area \approx \frac{1}{2} \cdot 0.080 \cdot 30.0$$

$$\approx 1.2 \text{ J}$$ ← **2 marks**

c) What does this area represent? **(1 mark)**

Work done on the spring, energy stored in spring ← 1 mark

9. During a roller coaster ride, the riders move through two loops, the second being one-half the radius of the first. The riders, however, travel at the same speed at the top of each of these two loops.



Using principles of physics, explain why the riders would experience a greater normal force at the top of the second smaller loop than at the top of the first larger loop. **(4 marks)**

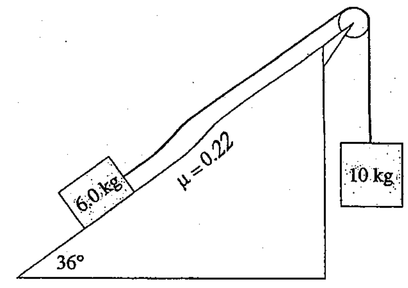
The centripetal force is the sum of the normal force and the force of gravity on the riders (1 mark). Since the radius decreases while the velocity does not change in the smaller loop the centripetal force must increase $\left(F_c \propto \frac{1}{R}\right)$ (2 marks). The normal force must increase to provide a greater centripetal force as force of gravity remains constant (1 mark).

END OF KEY

AUGUST 2003
WRITTEN RESPONSE

ANSWER KEY

1. Determine the acceleration of the system of masses shown below when it is released. **(7 marks)**



$F_{net} = 10(9.8) - 6.0(9.8)\sin 36° - 0.22(6.0)9.8\cos 36°$ **← 3 marks**

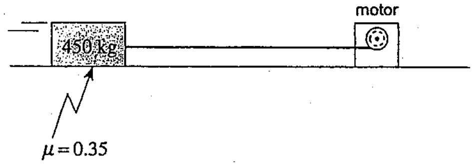
$F_{net} = 53.0 \text{ N}$ **← 1 mark**

$53.0 = (10 + 6.0)a$ **← 2 marks**

$a = 3.3 \text{ m/s}^2$ **← 1 mark**

24

2. A 3.7×10^3 W motor is 81% efficient. This motor is pulling a 450 kg block along a horizontal surface. If the coefficient of friction is 0.35, what is the speed of the block? **(7 marks)**



$$P = \frac{W}{t} = \frac{F \cdot d}{t}$$

$P = F \cdot v$ ← **2 marks**

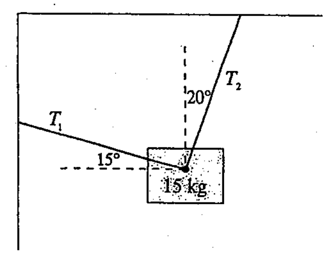
$0.81P = F_f \cdot v$ ← **1 mark**

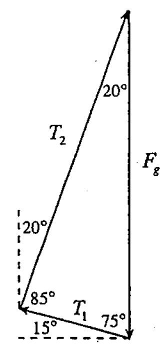
$0.81(3.7 \times 10^3) = \mu F_N v$ ← **1 mark**

$0.81(3.7 \times 10^3) = 0.35(450)9.8 \cdot v$ ← **2 marks**

$v = 1.9$ m/s ← **1 mark**

3. A 15 kg store sign is hung using two ropes as shown below. Determine the tension in each rope. **(7 marks)**





← **3 marks for the diagram**

$$\frac{T_1}{\sin 20°} = \frac{147}{\sin 85°}$$ ← **1 mark**

$T_1 = 50.5$ N

$= 50$ N ← **1 mark**

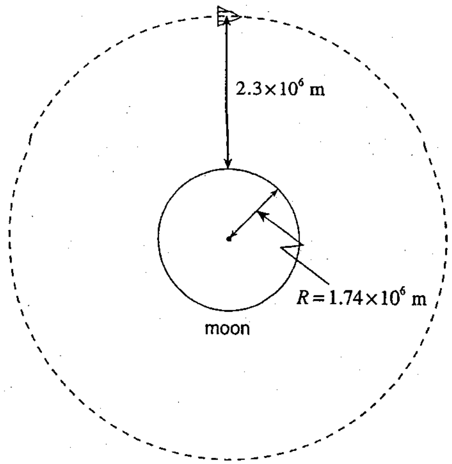
$$\frac{T_2}{\sin 75°} = \frac{147}{\sin 85°}$$ ← **1 mark**

$T_2 = 143$ N

$= 140$ N ← **1 mark**

24

4. A 1500 kg satellite orbits the moon at an altitude of 2.3×10^6 m.



What is the period for the satellite? **(7 marks)**

$F_c = F_g$ ← **2 marks**

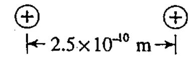
$\frac{m4\pi^2 r}{T^2} = \frac{Gm_m m}{r^2}$ ← **1 mark**

$T = \sqrt{\frac{4\pi^2 r^3}{Gm_m}}$ ← **1 mark**

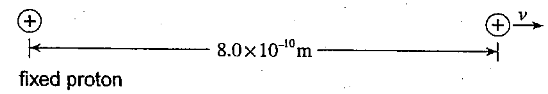
$= \sqrt{\frac{4\pi^2\times(4.0\times10^6)^3}{6.67\times10^{-11}\times7.35\times10^{22}}}$ ← **2 marks**

$= 23\,000$ s ← **1 mark**

5. Two protons are initially held at rest 2.5×10^{-10} m apart.



If one of the protons is released as shown below, what is its speed when it is 8.0×10^{-10} m from the fixed proton? **(7 marks)**



$E_{p_1} = E_{p_2} + E_k$

$E_{p_1} = \frac{kQ_1Q_2}{R_1}$

$= \frac{9.0\times10^9(1.6\times10^{-19})^2}{2.5\times10^{-10}}$

$E_{p_1} = 9.2\times10^{-19}$ J ← **2 marks**

$E_{p_2} = \frac{kQ_1Q_2}{R_2}$

$= \frac{9.0\times10^9(1.6\times10^{-19})^2}{8.0\times10^{-10}}$

$E_{p_2} = 2.9\times10^{-19}$ s ← **2 marks**

$E_{p_1} = E_{p_2} + E_k$

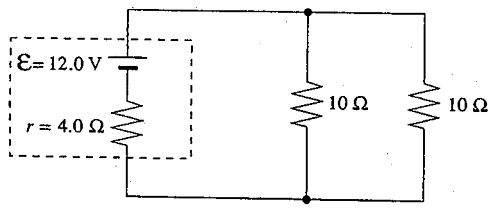
$9.2\times10^{-19} = 2.9\times10^{-19} + \frac{1}{2}mv^2$

$6.3\times10^{-19} = \frac{1}{2}(1.67\times10^{-27})v^2$ ← **2 marks**

$v = 2.7\times10^4$ m/s ← **1 mark**

24

6. a) For the circuit below, what is the terminal voltage of the battery? **(4 marks)**



$R_{parallel} = 5.0\ \Omega$

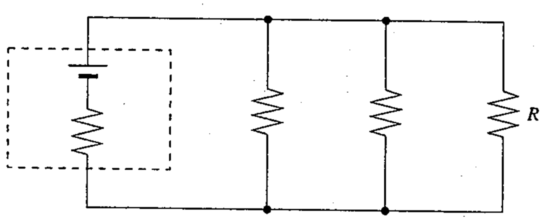
$R_{total} = 9.0\ \Omega$

$I_{total} = \frac{V}{R} = \frac{12.0}{9.0} = 1.33\text{ A}$

$Ir\text{ drop} = 1.33(4.0) = 5.3\text{ V}$

$V_{terminal} = 12.0 - 5.3 = 6.7\text{ V}$ ← **4 marks**

b) If resistor R is added in parallel to the circuit as shown, what is the effect on the terminal voltage? **(1 mark)**



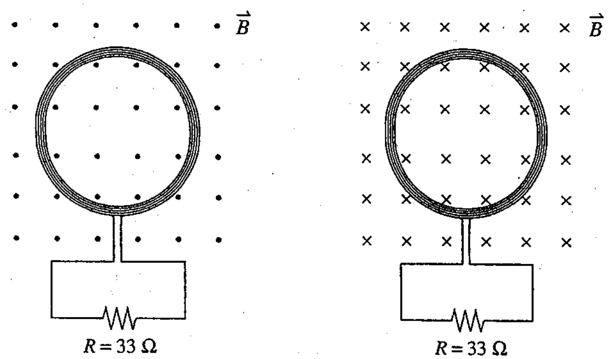
- ☐ increase
- ☐ no change
- ☑ decrease

c) Using principles of physics, explain your choice for b). **(4 marks)**

Additional *R* in parallel results in an overall lower *R*, thus an increase in current. (2 marks) As a consequence, a greater voltage drop *Ir* occurs across the internal resistance resulting in a smaller terminal voltage. (2 marks)

24

7. A 0.120 m diameter coil consisting of 200 loops is placed in a 0.35 T magnetic field. The magnetic field is changed to 0.25 T in the opposite direction in 0.80 s.



What is the magnitude of the current through the 33 Ω resistor connected to the coil? (Ignore the resistance of the coil.) **(7 marks)**

$$\mathcal{E} = \frac{-N\Delta\Phi}{\Delta t} \quad \leftarrow \textbf{1 mark}$$

$$= \frac{200\cdot\left(0.25-(-0.35)\right)\left(\pi\cdot 0.060^2\right)}{0.80} \quad \leftarrow \textbf{2 marks}$$

$$= \frac{200\cdot 0.60\cdot 0.0113}{0.80} \quad \leftarrow \textbf{1 mark}$$

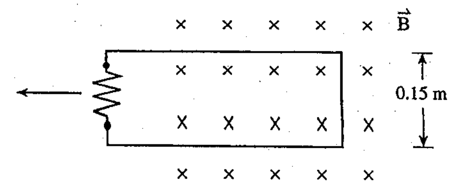
$$= 1.7\ \mathrm{V} \quad \leftarrow \textbf{1 mark}$$

$$\therefore I = \frac{\mathcal{E}}{R} \quad \leftarrow \textbf{1 mark}$$

$$= \frac{1.7}{33}$$

$$= 0.051\ \mathrm{A} \quad \leftarrow \textbf{1 mark}$$

8. A conducting loop is pulled at various speeds through a region of constant magnetic field strength.

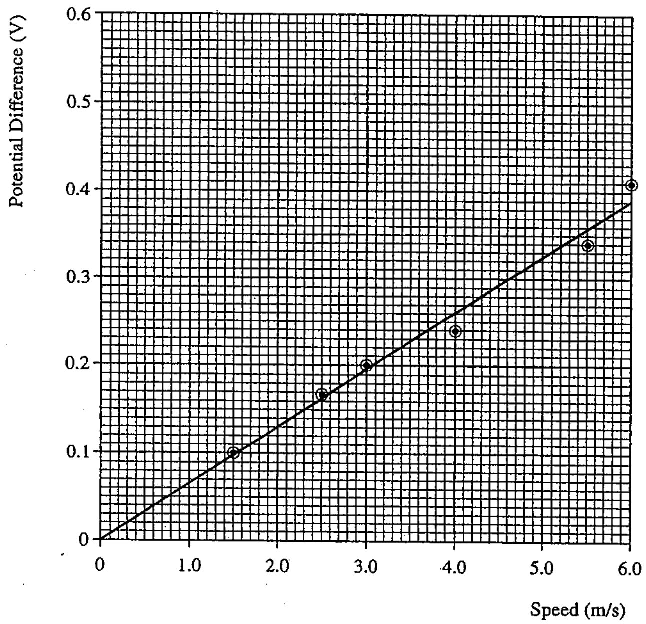


A student measures the potential difference across the resistor in the loop for each trial and records the following data.

POTENTIAL DIFFERENCE (V)	SPEED (m/s)
0.10	1.5
0.17	2.5
0.20	3.0
0.24	4.0
0.34	5.5
0.41	6.0

241

a) Plot a graph of the potential difference vs. speed. **(2 marks)**



b) Calculate the slope of your graph. (Include units.) **(1 mark)**

$$slope \approx 0.065\ \frac{\text{V}}{\text{m/s}} \cong 0.065\ \text{Vs/m}$$

c) What is the strength of the magnetic field? **(2 marks)**

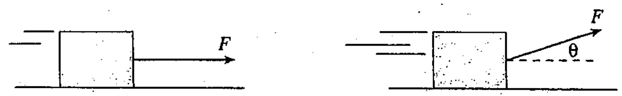
$$\varepsilon = B\ell v$$

$$\therefore slope = B\ell$$

$$\therefore B = \frac{slope}{\ell} = \frac{0.065}{0.15} \cong 0.43\ \text{T}$$

24

9. A crate is being accelerated across a rough concrete floor by a rope as shown in position 1 below. It is noticed that when the rope is lifted to a small angle θ as shown in position 2 the acceleration of the crate increases (F remains the same).



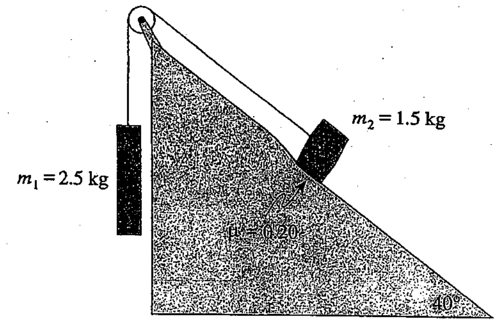
Position 1 Position 2

Using principles of physics, explain why this is the case. **(4 marks)**

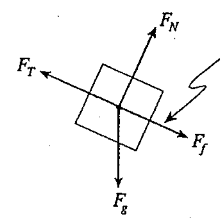
The pulling force in position 2 has a vertical component (1 mark) which balances a portion of F_g (1 mark), leaving F_N and therefore F_{fr} reduced (1 mark). The horizontal component of F is changed very little from 1 to 2 (1 mark).

END OF KEY

1. A system of masses is connected by a light cord passing over a pulley as shown in the diagram.



a) Draw a labelled free body diagram for mass m_2. **(2 marks)**



Note to markers:
either up or down incline

← **2 marks** for diagram

b) What is the magnitude of the acceleration of the system of masses? **(5 marks)**

$F_{net} = m_T a$

$$a = \frac{F_{net}}{m_T}$$

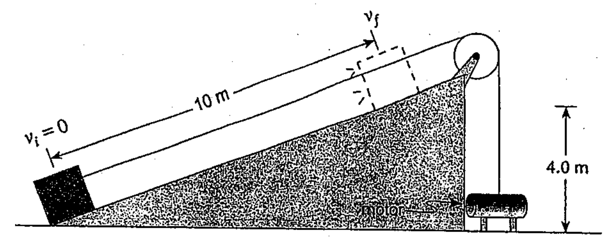
$$= \frac{F_{1_g} - F_{2_{fr}} - F_{2_{g_x}}}{(m_1 + m_2)} \quad \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} &= \frac{m_1 g - \mu m_2 g \cos\theta - m_2 g \sin\theta}{m_1 + m_2} \\ &\frac{2.5 \cdot 9.8 - 0.20 \cdot 1.5 \cdot 9.8 \cdot \cos 40 - 1.5 \cdot 9.8 \cdot \sin 40}{2.5 + 1.5} \end{aligned}\right\} \leftarrow \textbf{2}\tfrac{1}{2}\textbf{ marks}$$

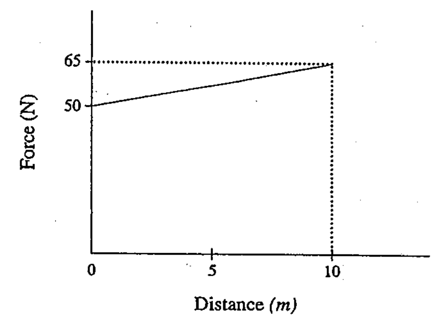
$$\frac{24.5 - 2.25 - 9.45}{2.5 + 1.5}$$

$$= 3.2 \text{ m/s}^2 \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

2. An electric motor and a rope are used to pull a 10 kg crate of car parts up an inclined plane as shown below. The crate starts out from rest on the ground and ends up with speed v_f at a height of 4.0 m above the ground.



The graph below shows the force exerted on the crate by the motor as it is pulled 10 m up the inclined plane.



24

a) How much work is done on the crate by the electric motor from $d = 0$ m to $d = 10$ m? **(3 marks)**

$W = F_{av} \cdot d$ ← **1 mark**

$W = (65+50)/2 \cdot 10 = 575$ J ← **2 marks**

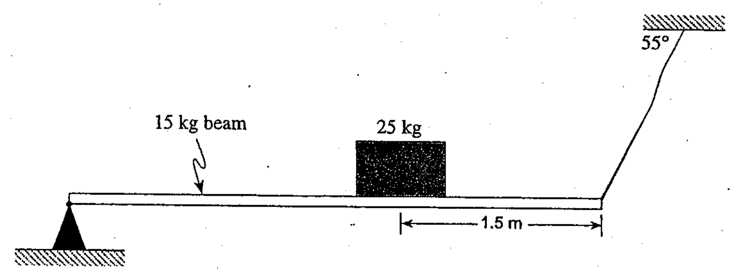
b) 150 J of heat energy is produced through friction during the 10 m pull. What is the final speed of the crate at $d = 10$ m? **(4 marks)**

$W = \Delta E_p + \Delta E_k + \Delta E_H$ ← **1 mark**

$575 = 10(9.8)4.0 + \frac{1}{2}10v_f^2 + 150$ ← **2 marks**

$v_f = 2.6$ m/s ← **1 mark**

3. **A uniform 4.0 m long beam with a mass of 15 kg rests on a pivot at one end and is kept horizontal by a cable at the other end. The beam is supporting a 25 kg mass as shown. What is the tension in the cable?** **(7 marks)**



$\Sigma\tau_{cw} = \Sigma\tau_{ccw}$ ← **1 mark**

$$\underbrace{F_b \cdot d_b}_{\text{1 mark}} + \underbrace{F_m \cdot d_m}_{\text{1 mark}} = \underbrace{F_c \cdot d_c \cdot \sin\theta_c}_{\text{1 mark}}$$

$$F_c = \frac{F_b d_b + F_m d_m}{d_c \cdot \sin\theta_c}$$

$$= \frac{15 \cdot 9.8 \cdot 2.0 + 25 \cdot 9.8 \cdot 2.5}{4.0 \cdot \sin 55} \quad \leftarrow \textbf{2 marks}$$

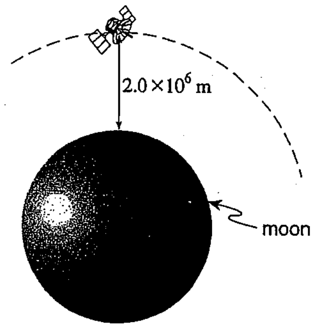
$$= \frac{294 + 612.5}{3.28}$$

$$= 277 \text{ N}$$

$$= 2.8 \times 10^2 \text{ N} \quad \leftarrow \textbf{1 mark}$$

24

4. A stationary 1.60×10^3 kg vehicle is taken from the surface of the moon and placed into a circular orbit at a height of 2.0×10^6 m above the surface of the moon. Its speed in this orbit is 1.15×10^3 m/s. How much work is required for this process? **(7 marks)**



$$E_{p\,surface} + W = E_{p\,altitude} + E_{k\,orbital} \qquad \leftarrow \textbf{1 mark}$$

$$-\frac{GmM}{R_1} + W = -\frac{GmM}{R_2} + \frac{1}{2}mv^2 \qquad \leftarrow \textbf{2 marks}$$

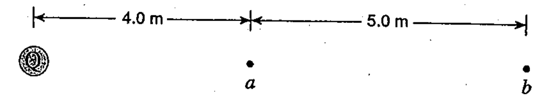
$$\left[\frac{-6.67 \times 10^{-11}(1.60 \times 10^3)(7.35 \times 10^{22})}{1.74 \times 10^6}\right] + W = \left[\frac{-6.67 \times 10^{-11}(1.60 \times 10^3)(7.35 \times 10^{22})}{3.74 \times 10^6} + \frac{1}{2}(1.60 \times 10^3)(1.15 \times 10^3)^2\right]$$

$$\left[-4.51 \times 10^9\right] + W = \left[-2.10 \times 10^9\right] + \left[1.06 \times 10^9\right] \qquad \leftarrow \textbf{3 marks}$$

$$-4.51 \times 10^9 + W = \left[-1.04 \times 10^9\right]$$

$$W = 3.5 \times 10^9 \text{ J} \qquad \leftarrow \textbf{1 mark}$$

5. The potential difference in moving from position a to position b $(\Delta V_{a \to b})$ in the diagram below is equal to $+400$ V. Determine the size and polarity of the charge Q. **(7 marks)**

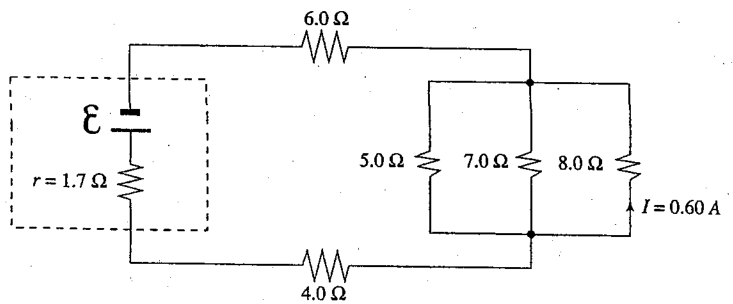


$$\left.\begin{aligned} \Delta V_{a \to b} &= \frac{kQ}{r_b} - \frac{kQ}{r_a} \\ 400 &= \frac{9.0 \times 10^9 Q}{9} - \frac{9.0 \times 10^9 Q}{4} \end{aligned}\right\} \leftarrow \textbf{5 marks}$$

$$Q = -3.2 \times 10^{-7} C \qquad \leftarrow \textbf{2 marks}$$

25

6. The current through the 8.0 Ω resistor shown below is 0.60 A. Determine the terminal voltage of the battery. **(7 marks)**



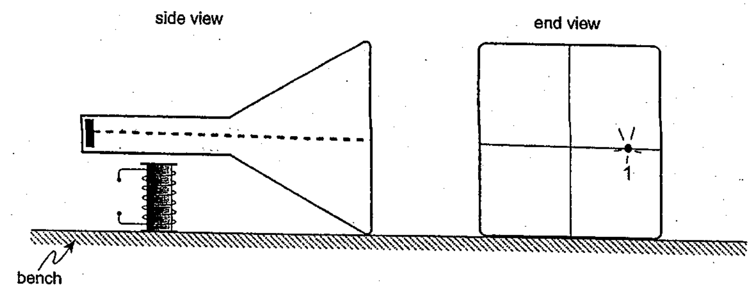
$V_{8.0\Omega} = 0.60 \cdot 8.0 = 4.8$ V ← **1 mark**

$I_{circuit} = 4.8/\left[1/\left(8.0^{-1}+7.0^{-1}+5.0^{-1}\right)\right] = 2.245\ A$ ← **3 marks**

$Terminal\ voltage = 2.245\left[6.0+4.0+1/\left(8.0^{-1}+7.0^{-1}+5.0^{-1}\right)\right]$ ← **2 marks**

$Terminal\ voltage = 27$ V ← **1 mark**

7. A solenoid placed beneath a cathode ray tube as shown below produces a magnetic field of 0.011 T on the electron beam causing it to hit the screen at position 1.



a) The electrons that make up the beam travel at 4.7×10^{7} m/s. What is the acceleration of the electrons in this field? **(5 marks)**

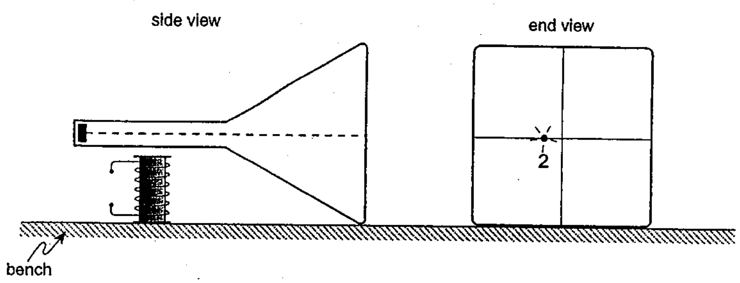
$a = \frac{F}{m}$ ← **1 mark**

$= \frac{qvB}{m}$ ← **2 marks**

$= \frac{1.6\times10^{-19}\times4.7\times10^{7}\times0.011}{9.11\times10^{-31}}$ ← **1 mark**

$= 9.1\times10^{16}\ \text{m/s}^2$ ← **1 mark**

b) The electron beam is then made to strike the screen at position 2. What two changes were made to the current in the solenoid? State the effect on the electron beam produced by each change. **(4 marks)**

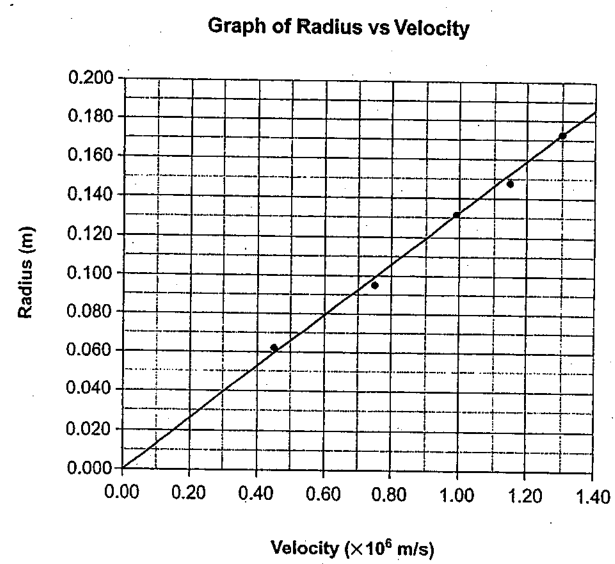


Change in Current	Effect
i) **Reduce current**	**Smaller deflection**
ii) **Change direction of current**	**Change direction of deflection**

8. In an experiment, protons are accelerated to different velocities and then subjected to a constant perpendicular magnetic field. The radii of the paths of the protons are measured against their velocities. The data is shown below.

RADIUS (m)	0.061	0.095	0.132	0.149	0.174
VELOCITY ($\times 10^6$ m/s)	0.44	0.76	0.98	1.16	1.31

a) Plot the data on the graph below and draw the best fit straight line. **(2 marks)**



← 2 marks for graph

25

b) Determine the slope of the line. (Include units.) **(2 marks)**

$$\text{slope} = m = \frac{\Delta R}{\Delta V} = \frac{0.187}{1.40\times10^{6}}$$

$m = 1.33\times10^{-7}\text{s}$ ← **2 marks**

c) Electrons replace the protons in the above experiment. The slope of the line will now be: **(1 mark)**

- ☐ larger than before
- ☐ same as before
- ☑ smaller than before

9. An object is dropped from a significant height above the surface of the Moon. It is observed to fall with increasing acceleration. Using principles of physics, give an explanation for this observation. **(4 marks)**

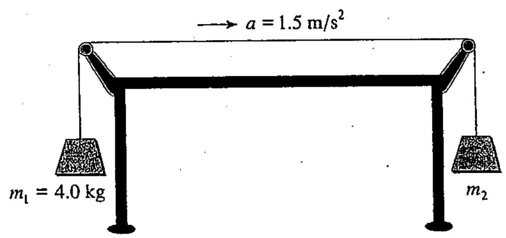
As the height decreases the force increases (3 marks).
As the force increases the acceleration increases (1 mark).

END OF KEY

JUNE 2004
WRITTEN RESPONSE

ANSWER KEY

1. Two masses are connected by a light cord passing over frictionless pulleys as shown in the diagram below.



a) What is m_2 if the system accelerates as shown? **(5 marks)**

$$F_{net} = m_s a$$

$$m_2 g - m_1 g = (m_1 + m_2)a \quad \leftarrow \textbf{3 marks}$$

$$9.8m_2 - 9.8(4) = (4.0 + m_2)1.5$$

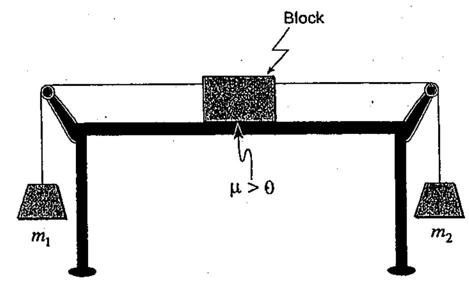
$$9.8m_2 - 39.6 = 6.0 + 1.5m_2$$

$$9.8m_2 - 1.5m_2 = 6.0 + 39.2$$

$$8.3m_2 = 45.2$$

$$m_2 = 5.4 \text{ kg} \quad \leftarrow \textbf{2 marks}$$

A block is then added to the system.

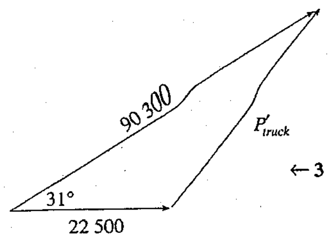


b) Adding the block decreases the acceleration of the system. Identify and explain two reasons for this decrease. **(4 marks)**

Since the system mass has increased, the acceleration must decrease $(a = F_{net}/m_{total})$. Since there is friction, the net force will decrease and the acceleration will be smaller yet. (4 marks)

25

2. A 4300 kg truck travelling at 21 m/s in the direction of 31° north of east collides with a stationary 1500 kg car. After the collision, the car has a speed of 15 m/s due east. What is the resulting speed of the truck? **(7 marks)**



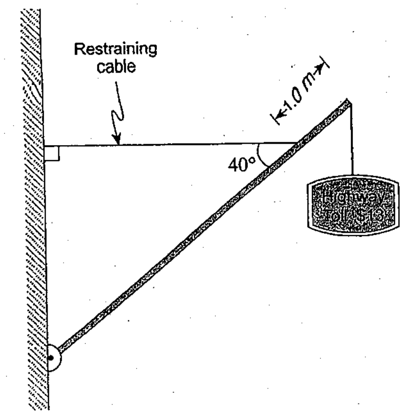
← **3 marks**

By cosine law:

$P'^{2}_{truck} = (22\ 500)^2 + (90\ 300)^2 - 2 \cdot 22\ 500 \cdot 90\ 300 \cdot \cos 31$ ← **2 marks**

$$\left.\begin{aligned} P'_{truck} &= 7.18 \times 10^4 \\ \therefore v'_{truck} &= \frac{7.18 \times 10^4}{4300} \\ &= 16.7 \\ &= 17 \text{ m/s} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

3. A sign is suspended from the end of a 6.0 m long uniform pole of mass 25 kg as shown. If the mass of the sign is 36 kg, what is the tension in the horizontal restraining cable? **(7 marks)**



$\Sigma \tau_c = \Sigma \tau_{cc}$ ← **1 mark**

$F_p d_p \sin\theta_p + F_s d_s \sin\theta_s = F_c d_c \sin\theta_c$ ← **3 marks**

$25 \cdot 9.8 \cdot 3.0 \cdot \sin 50 + 36 \cdot 9.8 \cdot 6.0 \cdot \sin 50 = F_c \cdot 5.0 \cdot \sin 40$

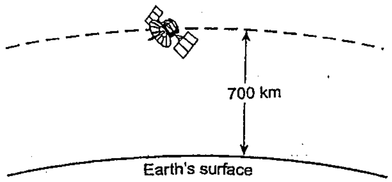
$F_c = \dfrac{25 \cdot 9.8 \cdot 3.0 \cdot \sin 50 + 36 \cdot 9.8 \cdot 6.0 \cdot \sin 50}{5.0 \cdot \sin 40}$ ← **2 marks**

$= \dfrac{563.0 + 1621.6}{3.21}$

$= 680 \text{ N}$ ← **1 mark**

25

4. A 4.20×10^4 kg satellite orbits the earth at an altitude of 700 km $(7.00\times10^5\text{ m})$.



a) What is the satellite's orbital speed at this altitude? **(4 marks)**

$$F_g = F_c$$

$$\frac{GmM}{R^2} = \frac{mv^2}{R}$$

$$v = \sqrt{\frac{GM}{R}}$$

$$= \sqrt{\frac{6.67\times10^{-11}(5.98\times10^{24})}{7.08\times10^6}}$$

$$v = 7.51\times10^3\text{ m/s}$$ ← **4 marks**

b) What is the satellite's total energy at this altitude? **(3 marks)**

$$E_T = E_p + E_k$$ ← **1 mark**

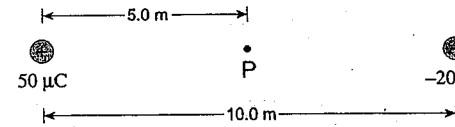
$$= \frac{-Gm_E m}{r} + \frac{1}{2}mv^2$$ ← **1 mark**

$$= \frac{-6.67\times10^{-11}\cdot5.98\times10^{24}\cdot4.20\times10^4}{7.08\times10^6} + \frac{1}{2}\cdot4.20\times10^4\cdot(7.51\times10^3)^2$$

$$= -2.37\times10^{12} + 1.18\times10^{12}$$

$$= -1.18\times10^{12}\text{ J}$$ ← **1 mark**

5. a) Determine the electric potential, relative to zero at infinity, at point P, midway between the two charges, shown below. **(5 marks)**



$$V = V_{50\mu C} + V_{-20\mu C}$$ ← **1 mark**

$$V = 9.0\times10^9(50\times10^{-6})/5.0 + 9\times10^9(-20\times10^{-6})/5.0$$ ← **3 marks**

$$V = 5.4\times10^4\text{ V}$$ ← **1 mark**

b) How much work would it take to move a −15 µC charge from point P to a position infinitely far away? **(2 marks)**

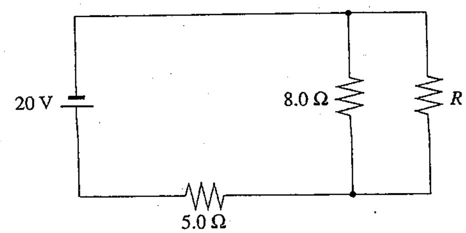
$$W = \Delta E_p = E_{pf} - E_{pi}$$

$$W = 0 - (54\times10^3)(-15\times10^{-6})$$ ← **1 mark**

$$W = 0.81\text{ J}$$ ← **1 mark**

25

6. The 8.0 Ω resistor in the circuit shown below dissipates 45 J of heat energy in 5.0 s. Determine the value of the resistor R. **(7 marks)**



$P_{8.0\Omega} = 45/5.0$

$P_{8.0\Omega} = 9.0\ W$ ← **1 mark**

$9.0 = (I_{8.0\Omega})^2 \cdot 8.0$

$I_{8.0\Omega} = 1.06\ A$ ← **1 mark**

$V_R = V_{8.0\Omega} = 1.06 \cdot 8.0 = 8.48\ V$ ← **1 mark**

$I_R = I_{circuit} - I_{8.0\Omega}$

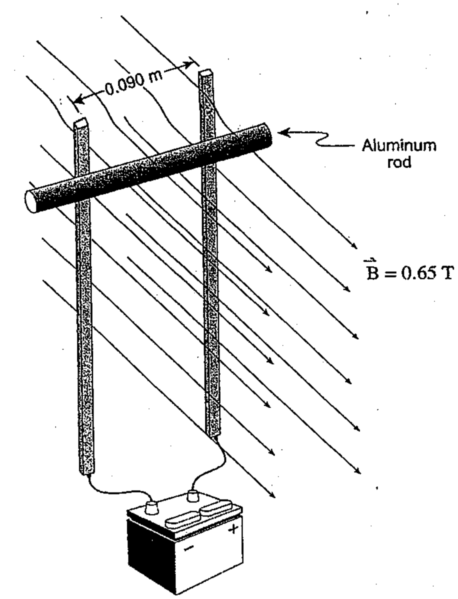
$I_R = (20 - 8.48)/(5.0) - 1.06$

$= 1.24\ A$ ← **2 marks**

$R = 8.48/1.24$

$= 6.8\ \Omega$ ← **2 marks**

7. A 0.13 kg aluminum rod maintains contact with two vertical metal rails. A voltage is applied across the metal rails and a horizontal magnetic field of 0.65 T exists across the whole apparatus as shown.



What current must flow through the aluminum rod to have it remain stationary? **(7 marks)**

$\vec{F}_g = \vec{F}_B$ ← **2 marks**

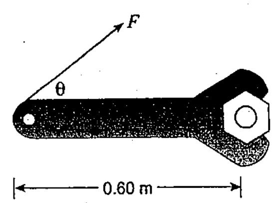
$mg = BI\ell$ ← **2 marks**

$= \dfrac{0.13 \times 9.8}{0.65 \times 0.090}$ ← **2 marks**

$= 22\ A$ ← **1 mark**

25

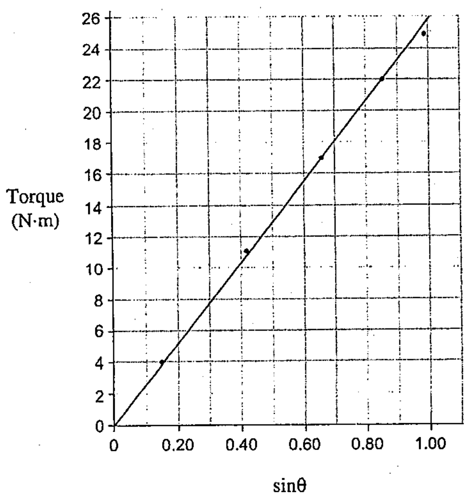
8. A student uses a wrench to apply a constant force to turn a nut. He applies the force at various angles and measures the amount of torque produced at each of the angles.



The torque data collected by the student along with the sine of the angles is shown below:

Torque (N·m)	4.0	11	17	22	25
sinθ	0.14	0.42	0.66	0.86	0.98

a) Plot a graph of torque versus $\sin\theta$ on the graph below. **(2 marks)**



← **2 marks for graph**

1 mark for line

1 mark for dots

$-\frac{1}{2}$ mark for wayward dots

b) Calculate the slope of your line including units. **(1 mark)**

slope ≈ 25 N·m ← **1 mark**

$\frac{1}{2}$ mark for numeric answer

$\frac{1}{2}$ mark for units

c) Use the slope of your graph to determine the amount of constant force the student used throughout his experiment. **(2 marks)**

$\tau = F \cdot \ell$

$$\left.\begin{aligned} F &= \frac{\text{slope}}{\ell} = \frac{\tau}{\ell} = \frac{25\ \text{N}\cdot\text{m}}{0.60} \\ &\approx 42\ \text{N} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

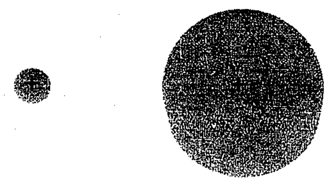
1 mark for equation and algebra

1 mark for substitution and answer

$-\frac{1}{2}$ mark for using 25 and it is not slope found in b)

258

9. A small plastic ball carrying a positive charge is held near a fixed large positively charged sphere as shown below. It is then released. Explain how and why the acceleration of the plastic ball changes as it moves away from the sphere. **(4 marks)**

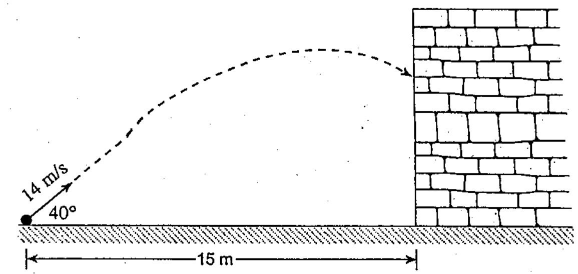


The size of the electrostatic force will be decreasing with separation from the sphere ($1\frac{1}{2}$ marks), so the acceleration of the plastic ball will be decreasing ($1\frac{1}{2}$ marks).

According to Coulomb's Law, where $F = \frac{kq_1q_2}{r^2}$ (1 mark).

END OF KEY

1. A 2.5 kg projectile is launched towards a brick wall as shown.



a) What are horizontal and vertical components of the launch velocity? **(2 marks)**

$v_x = v \cdot \cos\theta$

$= 14 \cdot \cos 40°$

$= 10.7$ m/s $\rightarrow$ 11 m/s $\leftarrow$ **1 mark**

$v_{y_i} = v \cdot \sin\theta$

$= 14 \sin 40°$

$= 9.0$ m/s $\leftarrow$ **1 mark**

b) How much time does it take for the projectile to reach the wall? **(2 marks)**

$t = \frac{d_x}{v_x}$ $\leftarrow$ **1 mark**

$= \frac{15}{10.7}$

$= 1.4$ s $\leftarrow$ **1 mark**

259

c) What is the projectile's impact speed with the wall? **(3 marks)**

$v_x = 10.7 \text{ m/s}$ ← **1 mark**

$v_{y_f} = v_{y_i} + at$

$= 9.0 + (-9.8)\cdot 1.40$ ← **1 mark**

$= -4.72 \text{ m/s}$

$v^2 = {v_x}^2 + {v_{y_f}}^2$

$= (10.7)^2 + (-4.72)^2$

$\therefore v = 11.7 \text{ m/s} \rightarrow 12 \text{ m/s}$ ← **1 mark**

2. A 5.30 kg wagon is moving at 2.00 m/s to the right. A 0.180 kg blob of putty moving at 32.0 m/s also to the right strikes the wagon and sticks to it.

a) With what speed will the wagon and the putty move after the collision? **(5 marks)**

$P_{initial} = P_{final}$ ← **1 mark**

$P_{putty} + P_{wagon} = P_{wagon\& putty}$ ← **1 mark**

$0.180 \cdot 32.0 + 5.30 \cdot 2.00 = (0.180 + 5.30) \cdot v$ ← **2 marks**

$5.76 + 10.6 = 5.48\, v$

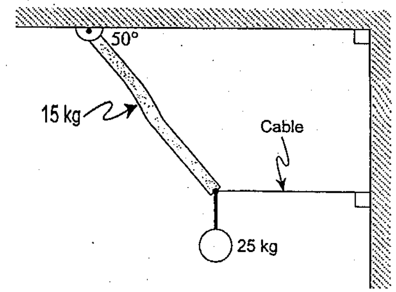
$v = 2.99 \text{ m/s}$ ← **1 mark**

260

b) Suppose the wagon had instead been struck by a ball with the same mass and speed as the putty and the ball rebounded to the left after the collision. How would the speed of the wagon compare with your answer to a)? Using principles of physics, give an explanation for your prediction. **(4 marks)**

The change in momentum of the incident ball is greater than the putty. As momentum is conserved, this means the change in momentum for the wagon must be larger, thus the speed is greater. (4 marks)

3. A 4.0 m long uniform pole with a mass of 15 kg is pivoted at one end and held in position by a horizontal cable at the other end. If a 25 kg mass is suspended from the end of the pole, what is the tension in the horizontal cable? **(7 marks)**



$$\Sigma\tau_{cw} = \Sigma\tau_{ccw}$$ **← 1 mark**

$$F_p d_p \sin\theta_p + F_m d_m \sin\theta_m = F_c d_c \sin\theta_c$$

$$15\cdot 9.8\cdot 2.0\cdot \sin 40 + 25\cdot 9.8\cdot 4.0\cdot \sin 40 = F_c\cdot 4.0\cdot \sin 50$$

$$\therefore F_c = \frac{15\cdot 9.8\cdot 2.0\cdot \sin 40 + 25\cdot 9.8\cdot 4.0\cdot \sin 40}{4.0\cdot \sin 50}$$

$$= \frac{189.0 + 629.9}{3.06}$$

← 5 marks

$$= 2.7\times 10^2 \text{ N}$$ **← 1 mark**

26

4. A 7.5×10^4 kg space vehicle leaves the surface of the earth with a speed of 1.3×10^4 m/s. What will its speed be when it is infinitely far from the earth? **(7 marks)**

$$E_i = E_f \qquad \leftarrow \textbf{1 mark}$$

$$E_{p_i} + E_{k_i} = E_{p_f} + E_{k_f} \qquad \leftarrow \textbf{1 mark}$$

$$-\frac{GmM}{R_E} + \frac{1}{2}mv_i^2 = 0 + \frac{1}{2}mv_f^2 \qquad \leftarrow \textbf{1 mark}$$

$$\left[\frac{-6.67\times10^{-11}(5.98\times10^{24})}{6.38\times10^6}\right] + \left[\frac{1}{2}(1.3\times10^4)^2\right] = \frac{1}{2}v_f^2 \qquad \leftarrow \textbf{2 marks}$$

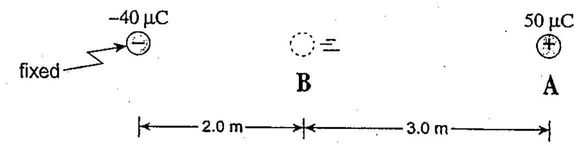
$$-6.25\times10^7 + 8.45\times10^7 = \frac{1}{2}v_f^2 \qquad \leftarrow \textbf{1 mark}$$

$$\frac{1}{2}v_f^2 = 2.2\times10^7$$

$$v_f^2 = 4.4\times10^7$$

$$v_f = 6.6\times10^3 \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

5. A 1.0×10^{-3} kg styrofoam ball carrying 50 μC of charge is released from rest from position A as shown in the diagram below. ($1\ \mu C = 1\times10^{-6}$ C)



a) Determine the change in electric potential energy, ΔE_p, of the ball as it moves from position A to position B. **(5 marks)**

$$\Delta E_p = k\frac{Q_1Q_2}{r} - k\frac{Q_1Q_2}{r_0} \qquad \leftarrow \textbf{1 mark}$$

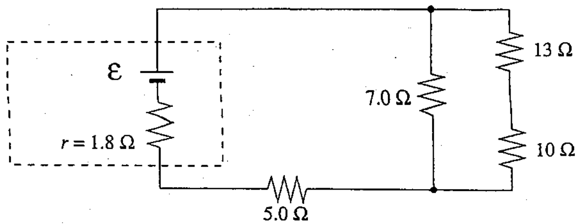
$$\left.\begin{aligned} \Delta E_p &= 9\times10^9\frac{(50\times10^{-6})(-40\times10^{-6})}{2} - 9\times10^9\frac{(50\times10^{-6})(-40\times10^{-6})}{5} \\ \Delta E_p &= -9-(-3.6) \\ \Delta E_p &= -5.4 \text{ J} \end{aligned}\right\} \leftarrow \textbf{4 marks}$$

b) What is the speed of the ball as it reaches position B? ($v_i = 0$ at A) **(2 marks)**

$$\left.\begin{aligned} -\Delta E_p &= \Delta E_k \\ -(-5.4) &= \frac{1}{2}(0.0010)v^2 - 0 \\ v &= 1.0\times10^2 \text{ m/s} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

26

6. The internal resistance of the battery shown in the circuit below dissipates 10 W of power. Determine the current through the 13 Ω resistor. **(7 marks)**



$10 = I^2_{circuit} \cdot 1.8$ ← **2 marks**

$I_{circuit} = 2.357$ A ← **1 mark**

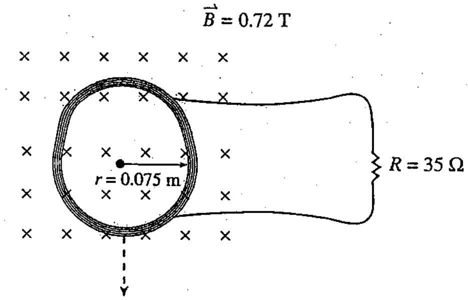
$R_T = \left[\frac{1}{7} + \frac{1}{23}\right]^{-1} + 5 + 1.8 = 12.12\ \Omega$ ← **1 mark**

$\varepsilon = IR = (2.357)(12.17) = 26.68$ V ← **1 mark**

$V_{\parallel} = 28.68 - (6.8 \times 2.357) = 12.65$ V ← **1 mark**

$I_{13} = \frac{V_{\parallel}}{R_{13,10}} = \frac{12.65}{23} = 0.55$ A ← **1 mark**

7. A 480-turn circular coil of radius 0.075 m is placed in a perpendicular magnetic field of 0.72 T. The coil is connected to a resistor of 35 Ω as shown.



a) Calculate the average current through the resistor as the coil is removed from the magnetic field in a time of 0.22 s. **(6 marks)**

$\varepsilon = \frac{N\Delta BA}{t}$ ← **1 mark**

$A = \pi(0.075)^2 = 0.0177$ ← **1 mark**

$= \frac{480 \times 0.72 \times \pi \times 0.075^2}{0.22}$ ← **2 marks**

$= 27.8$ V ← **1 mark**

$I = \frac{V}{R} = \frac{27.8}{35}$ ← **1 mark**

$I = 0.79$ A ← **1 mark**

b) In which direction will the current flow in the coil? **(1 mark)**

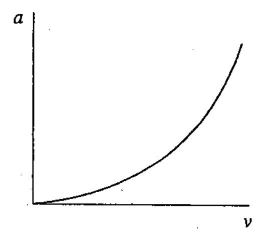
- [x] clockwise
- [ ] counterclockwise

2

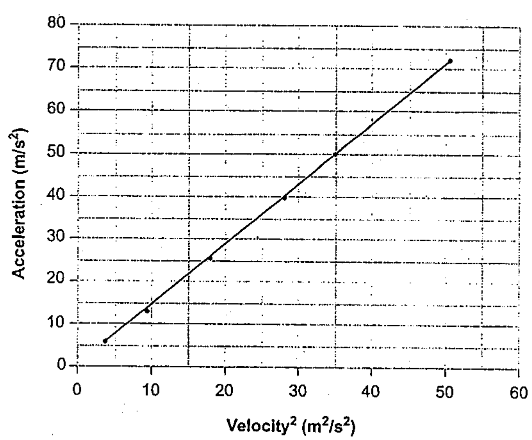
8. A student measures the acceleration of a lab cart as it moves at different speeds around a circular horizontal path. The data collected by the student is shown below:

ACCELERATION (m/s^2)	5.7	12.9	25.2	40	49.7	72
VELOCITY (m/s)	2.0	3.0	4.2	5.3	5.9	7.1
VELOCITY^2 (m^2/s^2)	4.0	9.0	17.6	28.1	34.8	50.4

When a graph of acceleration versus velocity is plotted a curve results as shown.



a) Manipulate the **velocity data** and use it to plot a straight line on the graph below. **(3 marks)**



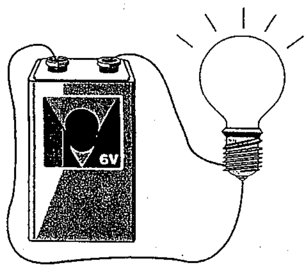
b) Calculate the slope of this graph including units. **(2 marks)**

$$\text{slope} = \frac{\Delta a}{\Delta v^2} = \frac{72-5.7}{50.4-4} = 1.43\ \frac{m/s^2}{m^2/s^2} \quad \leftarrow \textbf{2 marks}$$

$$= 1.4\ m^{-1}$$

26

9. Explain why a 6.0 V battery feels warm to the touch when it is being used to run a low resistance light bulb. (4 marks)



Low resistance light bulb will result in a high current through the battery (1 mark). This high current is passing through the battery's internal resistance (1 mark), resulting in the dissipation of an appreciable amount of heat (2 marks).

END OF KEY

PROVINCIAL

EXAMINATION

SPECIFICATIONS

2004-2005

26

PHYSICS 12

EXAMINATION SPECIFICATIONS

SEPTEMBER 2004

Assessment Department

The information in this booklet is intended to be helpful for both teachers and students.
Teachers are encouraged to make this information available to all students.

PHYSICS 12

The intent of the *Examination Specifications* is to convey to the classroom teacher and student how the Physics 12 curriculum will be tested on the provincial examinations. The Table of Specifications provides percentage weightings for each of the eleven curriculum organizers as well as the cognitive levels that are applied to questions. A detailed description of examinable material within each curriculum organizer will be found in the curriculum section of the *Physics 11 and 12 Integrated Resource Package* (IRP), *1996* and in Appendix A of that package.

Replaces All Previous Versions of Physics 12 Examination Specifications

1. The Physics 12 Provincial Examinations will conform to the curriculum organizers of the *Physics 11 and 12 Integrated Resource Package, 1996.*
2. It is essential that teachers thoroughly familiarize themselves with the content of the *Physics 11 and 12 Integrated Resource Package, 1996.*
3. The eleven curriculum organizers are described in greater detail as Prescribed Learning Outcomes in Appendix A of the *Physics 11 and 12 Integrated Resource Package, 1996.*
4. The Physics 12 Provincial Examination will include a five-mark written-response question that addresses the prescribed learning outcome A10.

   "It is expected that students will gather and organize data, produce and interpret graphs, and determine relationships between variables."

   Two examples of this particular type of five-mark question appear in Appendix I. These questions are at the Higher Mental Process (HMP) cognitive level.
5. Aside from an approved calculator, electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.

It is expected that there will be a difference between school marks and provincial examination marks for individual students. Some students perform better on classroom tests and others on provincial examinations. School assessment measures performance on all curricular outcomes, whereas provincial examinations may only evaluate performance on a sample of these outcomes.

The provincial examination represents 40% of the student's final letter grade and the classroom mark represents 60%.

Acknowledgement
The Assessment Department wishes to acknowledge the contribution of British Columbia teachers in the preparation and review of this document.

TABLE OF CONTENTS

PHYSICS 12

DESCRIPTION OF THE PROVINCIAL EXAMINATION

The Table of Specifications (page 3) outlines the curriculum organizers, sub-organizers, and the cognitive level emphases covered on the provincial examination. A detailed description of examinable material within each curriculum organizer will be found in the *Physics 11 and 12 Integrated Resource Package, 1996.*

The provincial examination is divided into **two** parts:

PART A: There will be 35 **multiple-choice** questions each worth 2 marks for **70%** of the examination (70 marks).

Most of these questions will be problems requiring an understanding of basic definitions, concepts, and the use of single equations, while a few questions may be more complex.

PART B: There will be 6 **written-response** questions worth **30%** of the examination (30 marks).

Most of these questions will be problems requiring an understanding of basic concepts while some may require an explanation of basic concepts.

In answering the written-response questions the following points should be noted:

1. Students are expected to communicate their knowledge and understanding of physics principles in a clear and logical manner. Partial marks will be awarded for steps and assumptions leading to a solution. Full marks will **not** be awarded for providing a final answer **only**.
2. If students are unable to determine the value of a quantity required in order to proceed, they may assume a reasonable value and continue toward the solution. Such a solution, however, may not be eligible for full marks.
3. Final answers must include appropriate **units**.
4. Marks will not be deducted for answers expressed to **two** or **three** significant figures.

The provincial examination booklet will contain the tables of constants, mathematical equations, and basic physics formulae found in Appendices II, III and IV.

26

A calculator is essential for the Physics 12 Provincial Examination. The calculator must be a hand-held device designed primarily for mathematical computations involving logarithmic and trigonometric functions and may be capable of performing graphing functions. Computers, calculators with a QWERTY keyboard or symbolic manipulation abilities, and electronic writing pads will not be allowed. Students must not bring any external devices (peripherals) to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, CD-ROMs, libraries or external keyboards. Students may have more than one calculator available during the examination, of which one may be a scientific calculator. Calculators may not be shared and must not have the ability to either transmit or receive electronic signals. In addition to an approved calculator, students will be allowed to use rulers, compasses, and protractors during the examination.

Calculators must not have any information programmed into the memory which would not be acceptable in paper form. Specifically, calculators must not have any built-in notes, definitions, or libraries. There is no requirement to clear memories at the beginning of the examination but the use of calculators with built-in notes is equivalent to the use of notes in paper form. Any student deemed to have cheated on a provincial examination will receive a "0" on that examination and will be permanently disqualified from the Provincial Examination Scholarship Program.

This examination is designed to be completed in **two hours**. *Students may, however, take up to 30 minutes of additional time to finish.*

PHYSICS 12
TABLE OF SPECIFICATIONS FOR THE PROVINCIAL EXAMINATION

CURRICULUM			COGNITIVE LEVEL			TOTAL
ORGANIZERS	**SUB-ORGANIZERS**	**SUB-TOTAL**	Knowledge	Understanding and Application	Higher Mental Processes	%
Vector Kinematics in Two Dimensions	A. Vectors and Relative Velocity	9		← 4 →		18
	B. Motion with Constant Acceleration			← 5 →		
- - - - - and - - - - - **Dynamics** and **Vector Dynamics**	C. Forces	9		← 4 →		
	D. Two-Dimensional Dynamics			← 5 →		
Work, Energy and Power	E. Work, Energy and Power	6		← 6 →		12
- - - - - and - - - - - **Momentum**	F. One-Dimensional Momentum G. Two-Dimensional Momentum	6		← 6 →		
Equilibrium	H. Equilibrium	12		← 12 →		12
Circular Motion	I. Circular Motion	8		← 16 →		16
- - - - - and - - - - - **Gravitation**	J. Gravitation	8				
Electrostatics	K. Electric Force and Electric Field L. Electric Potential Energy and Electric Potential	12		← 12 →		12
Electric Circuits	M. Ohm's Law and Kirchhoff's Laws N. Power and Energy	12		← 12 →		12
Electromagnetism	O. Magnetic Forces	9		← 18 →		18
	P. Magnetic Induction	9				
	TOTAL 100%	100	10	80	10	100

The values in this table are approximate and may fluctuate.

Examination configuration: 70 marks in multiple-choice format (35 questions worth two marks each)
30 marks in written-response format

26

DESCRIPTION OF COGNITIVE LEVELS

The following three cognitive levels are based on a modified version of Bloom's taxonomy (Taxonomy of Educational Objectives, *Bloom* et al., *1956). Bloom's taxonomy describes six cognitive categories: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. For ease of classification, the six cognitive categories have been collapsed into three.*

Knowledge

Knowledge is defined as including those behaviours and test situations that emphasize the remembering, either by recognition or recall, of ideas, material, or phenomena. Incorporated at this level is knowledge of terminology, specific facts (dates, events, persons, etc.), conventions, classifications and categories, criteria, methods of inquiry, principles and generalizations, theories and structures.

Understanding and Application

Understanding refers to responses that represent a comprehension of the literal message contained in a communication. This means that the student is able to translate, interpret or extrapolate. Interpretation involves the reordering of ideas (inferences, generalizations, or summaries). Extrapolation includes estimating or predicting based on an understanding of trends or tendencies.

Application requires the student to apply an appropriate abstraction (theory, principle, idea, method) to a new situation.

Higher Mental Processes

Included at this thought level are the processes of analysis, synthesis, and evaluation.

Analysis involves the ability to recognize unstated assumptions, to distinguish facts from hypotheses, to distinguish conclusions from statements that support them, to recognize which facts or assumptions are essential to a main thesis or to the argument in support of that thesis, and to distinguish cause-effect relationships from other sequential relationships.

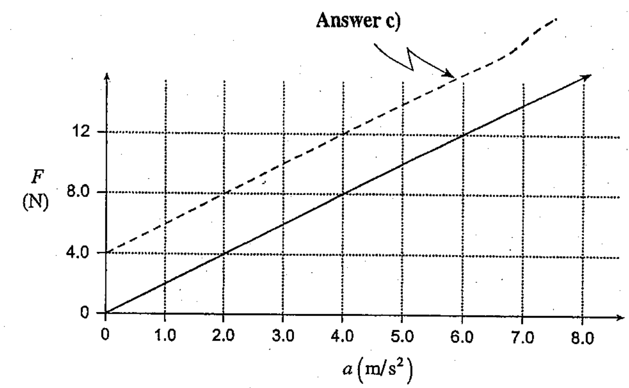
Synthesis involves the production of a unique communication, the ability to propose ways of testing hypotheses, the ability to design an experiment, the ability to formulate and modify hypotheses, and the ability to make generalizations.

Evaluation is defined as the making of judgments about the value of ideas, solutions, and methods. It involves the use of criteria as well as standards for appraising the extent to which details are accurate, effective, economical, or satisfying. Evaluation involves the ability to apply given criteria to judgments of work done, to indicate logical fallacies in arguments, and to compare major theories and generalizations.

Questions at the higher mental processes level subsume both *knowledge* and *understanding and application* levels.

APPENDIX I: PLO A10 SAMPLE QUESTIONS

1. A student performs an experiment by applying a force F to a frictionless cart, giving it an acceleration a. He plots a graph of F versus a, as shown below.



a) Determine the slope of this graph, expressing your answer in appropriate units. **(2 marks)**

$2.0\,\frac{N}{m/s^2}$ or 2.0 kg

b) What does the slope of your graph represent? **(1 mark)**

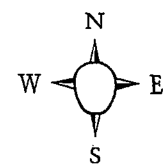
A mass of 2.0 kg

c) An identical cart with the same applied force F is placed on a different surface and now experiences a constant friction force of 4.0 N. On the axes above, sketch the graph that corresponds to this situation. (Use a pencil so that you may make changes to your answer, if necessary.) **(2 marks)**

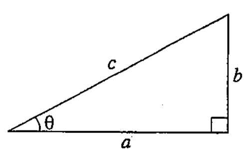
See graph for response.

APPENDIX III: MATHEMATICAL FORMULAE

METRIC PREFIXES			
Prefix	Symbol	Numerical	Exponential
mega	M	1,000,000	10^6
kilo	k	1,000	10^3
hecto	h	100	10^2
deca	da	10	10^1
		1	10^0
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000001	10^{-6}



For Right-angled Triangles:

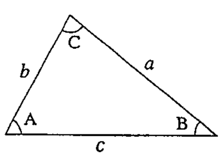


$a^2 + b^2 = c^2$

$\sin\theta = \frac{b}{c}$ $\cos\theta = \frac{a}{c}$ $\tan\theta = \frac{b}{a}$

$\text{area} = \frac{1}{2}ab$

For All Triangles:



$\text{area} = \frac{1}{2}\text{base} \times \text{height}$

Sine Law: $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

Cosine Law: $c^2 = a^2 + b^2 - 2ab\,\cos C$

Circle:

Circumference $= 2\pi r$

Area $= \pi r^2$

Quadratic Equation:

If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

IV: PHYSICS FORMULAE

Vector Kinematics in Two Dimensions:

$v = v_0 + at$ $\bar{v} = \frac{v + v_0}{2}$

$v^2 = v_0^2 + 2ad$ $d = v_0 t + \frac{1}{2}at^2$

Vector Dynamics:

$F_{net} = ma$ $F_g = mg$

$F_{fr} = \mu F_N$

Work, Energy, and Power:

$W = Fd$ $E_p = mgh$

$E_k = \frac{1}{2}mv^2$ $P = \frac{W}{\Delta t}$

Momentum:

$p = mv$ $\Delta p = F\Delta t$

Equilibrium:

$\tau = Fd$

Circular Motion:

$T = \frac{1}{f}$

$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$

Gravitation:

$F = G\frac{m_1 m_2}{r^2}$ $E_p = -G\frac{m_1 m_2}{r}$

Electrostatics:

$F = k\frac{Q_1 Q_2}{r^2}$ $E = \frac{F}{Q}$ $E = \frac{kQ}{r^2}$

$\Delta V = \frac{\Delta E_p}{Q}$ $E = \frac{\Delta V}{d}$

$E_p = k\frac{Q_1 Q_2}{r}$ $V = \frac{kQ}{r}$

Electric Circuits:

$I = \frac{Q}{\Delta t}$ $V = IR$

$V_{terminal} = \mathcal{E} \pm Ir$ $P = VI$

Electromagnetism:

$F = BIl$ $F = QvB$

$B = \mu_0 n I = \mu_0 \frac{N}{l} I$ $\mathcal{E} = Blv$

$\Phi = BA$ $\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$

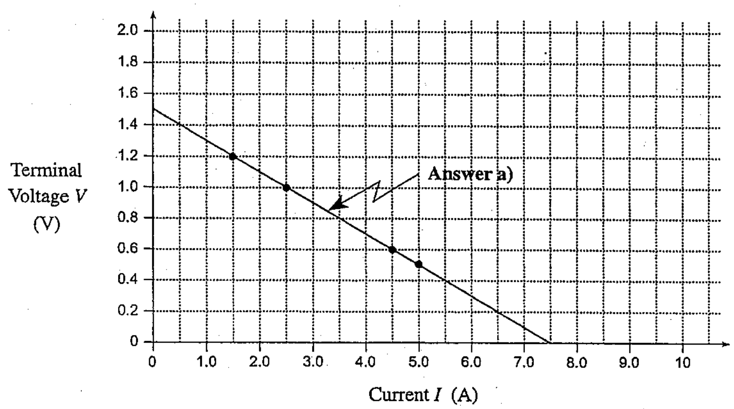
$V_{back} = \mathcal{E} - Ir$

$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$

21

2. Using a cell with an emf of 1.50 V, a student measures and records various values of the terminal voltage V for different current values I, as shown below.

V (V)	1.20	1.00	0.60	0.50
I (A)	1.50	2.50	4.50	5.00



a) Plot a graph of V versus I on the axes above. **(2 marks)**

See graph for response.

b) What maximum current could this cell supply? **(1 mark)**

7.5 A

c) What is the internal resistance of the cell? **(2 marks)**

$$V_T = \mathcal{E} - Ir$$

substitute any data point **or** $-r = slope$

$$1.2 = 1.5 - (1.5)r \qquad r = 0.20\ \Omega$$

$$r = 0.20\ \Omega$$

APPENDIX II: FUNDAMENTAL CONSTANTS AND PHYSICAL DATA

Gravitational constant .... $G = 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$

Constant in Coulomb's Law .... $k = 9.00 \times 10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2$

Elementary charge .... $e = 1.60 \times 10^{-19}\ \text{C}$

Mass of electron .... $m_e = 9.11 \times 10^{-31}\ \text{kg}$

Mass of proton .... $m_p = 1.67 \times 10^{-27}\ \text{kg}$

Permeability of free space .... $\mu_o = 4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}$

Speed of light .... $c = 3.00 \times 10^{8}\ \text{m/s}$

Earth

- radius .... $= 6.38 \times 10^{6}\ \text{m}$
- mass .... $= 5.98 \times 10^{24}\ \text{kg}$
- acceleration due to gravity at the surface of Earth (for the purposes of this examination) .... $g = 9.80\ \text{m/s}^2$
- period of rotation .... $= 8.61 \times 10^{4}\ \text{s}$
- radius of orbit around Sun .... $= 1.50 \times 10^{11}\ \text{m}$
- period of orbit around Sun .... $= 3.16 \times 10^{7}\ \text{s}$

Moon

- radius .... $= 1.74 \times 10^{6}\ \text{m}$
- mass .... $= 7.35 \times 10^{22}\ \text{kg}$
- period of rotation .... $= 2.36 \times 10^{6}\ \text{s}$
- radius of orbit around Earth .... $= 3.84 \times 10^{8}\ \text{m}$
- period of orbit around Earth .... $= 2.36 \times 10^{6}\ \text{s}$

Sun

- mass .... $= 1.98 \times 10^{30}\ \text{kg}$

2
II

APPENDIX V: COMMON TERMS

The following list of common terms may be used in the construction of items for the Physics 12 examination.

altitude
apparent weight
billiard or pool ball
dissipate
elapse
elevation
extrapolate
Ferris wheel
freely falling object
geosynchronous
Hertz
hinged
horizon
jammed
line of best fit
loop-the-loop
merry-go-round
parallel plates
rebound
roller coaster
see-saw
suspend
teeter-totter
turns
Weber
weightless
windings