Physics 12

August 2002 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.	D	K	2	1	B6	16.	B	U	2	4	J9, 10
2.	B	U	2	1	B8	17.	B	U	2	4	J6, 7
3.	D	U	2	1	B2; D6	18.	C	K	2	5	L7
4.	C	K	2	1	C6	19.	D	U	2	4	K2
5.	B	U	2	1	C8; D6	20.	C	H	2	5	L8; K5
6.	A	K	2	1	E5	21.	A	K	2	6	M6
7.	C	U	2	2	E7	22.	C	U	2	6	N2; M2
8.	C	U	2	2	F3	23.	B	H	2	6	M11, 7
9.	A	K	2	3	H4	24.	C	K	2	7	P1
10.	B	U	2	3	H3	25.	D	U	2	7	O3
11.	B	U	2	3	H5, 11	26.	A	U	2	7	O6; F1
12.	B	K	2	4	I1; C3	27.	A	U	2	7	O8; A10
13.	A	U	2	4	I5	28.	B	U	2	7	P9
14.	C	U	2	4	I4; C8	29.	A	U	2	7	P11, 12
15.	D	U	2	4	I4	30.	D	H	2	7	P5; B2

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

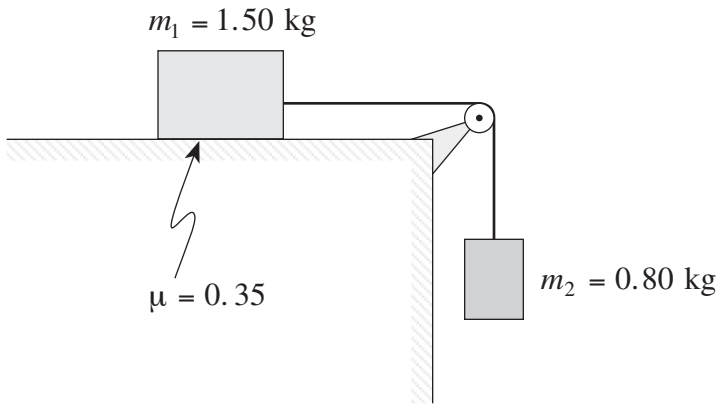
Written Response = 60 marks

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

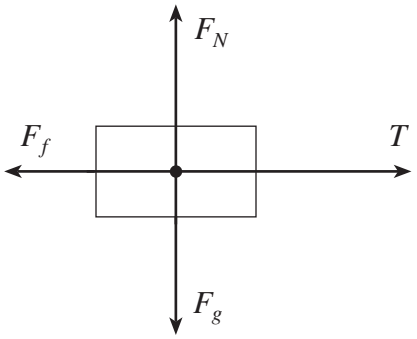
LEGEND:

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

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**

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

$$T - F_f = m_1 a$$

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

Combining:

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

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

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

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

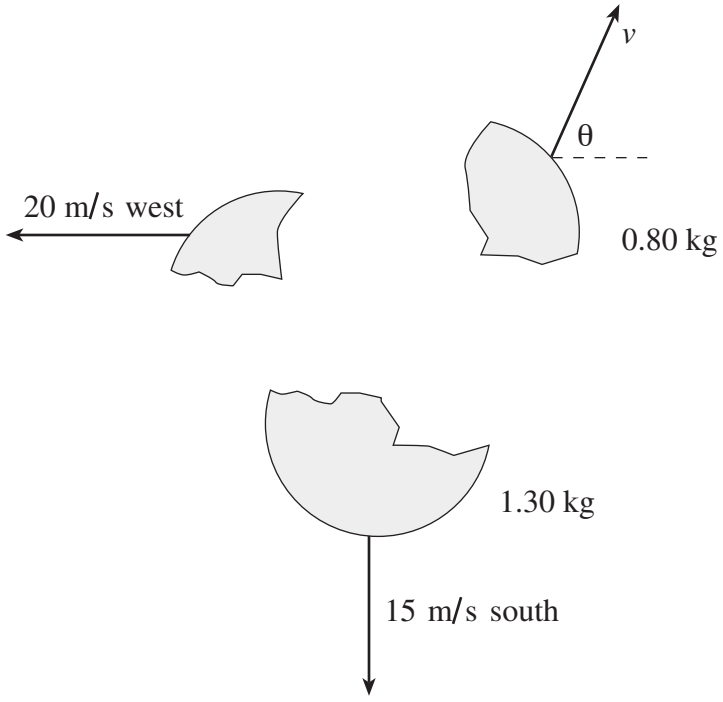
Substituting:

$$T = m_1 a + F_f$$

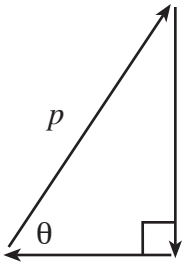
$$= 1.50 \cdot 1.2 + 0.35 \cdot 1.50 \cdot 9.8$$

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

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)**



$15 \cdot 1.30 = 19.5 \text{ kg} \cdot \text{m/s}$

← 3 marks

$20 \cdot 0.90 = 18 \text{ kg} \cdot \text{m/s}$

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

$p = 26.5 \text{ kg} \cdot \text{m/s}$ **← 1 mark**

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

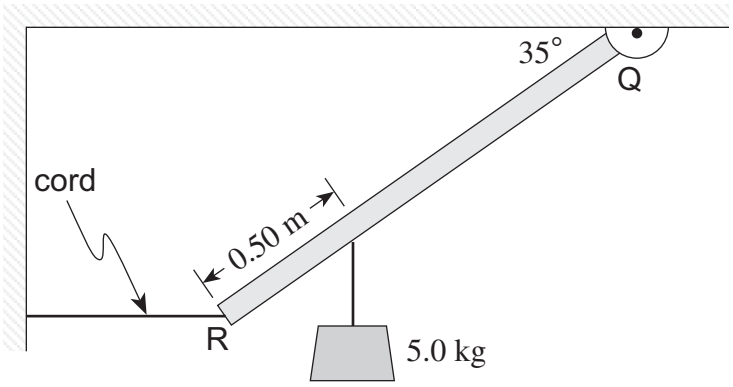
$= \frac{26.5}{0.80}$

$= 33 \text{ m/}s$ **← 1 mark**

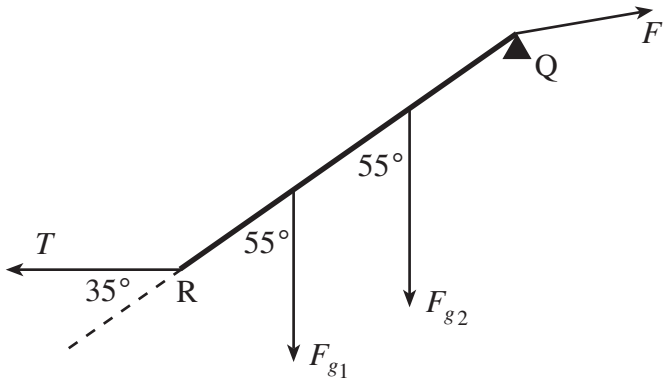
$\theta = \tan^{-1}\left(\frac{19.5}{18}\right)$

$= 47°$ **← 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 ½ 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 ½ marks**

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

$= 76$ 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

$$F_{net} = ma_c$$

$$F = \frac{GmM}{R^2} \quad \leftarrow \textbf{1 mark}$$

$$F_g = \frac{m4\pi^2 R}{T^2} \quad \leftarrow \textbf{1 mark}$$

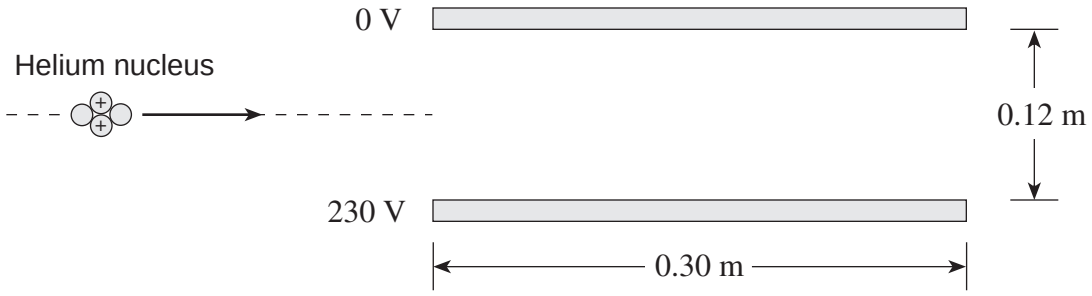
$$\frac{GmM}{R^2} = \frac{m4\pi^2 R}{T^2} \quad \leftarrow \textbf{2 marks}$$

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

$$R^3 = \frac{\left(6.67 \times 10^{-11}\right)\left(6.42 \times 10^{23}\right)\left(8.86 \times 10^{4}\right)^2}{4\pi^2} \quad \leftarrow \textbf{2 marks}$$

$$R = 2.0 \times 10^{7}\ \text{m} \quad \leftarrow \textbf{1 mark}$$

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)**

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

$a = \frac{qV}{md}$ **← 3 marks**

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

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

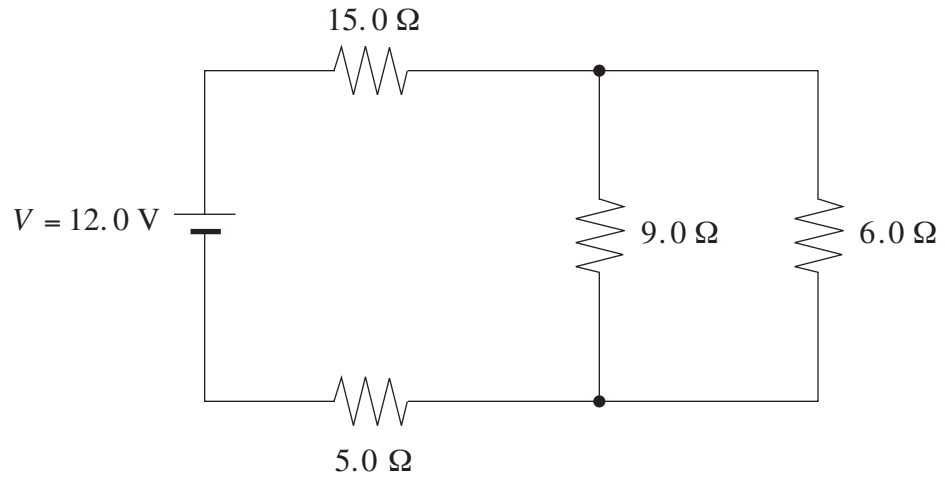
b) A proton travelling at the same velocity as the helium nucleus is then sent through these same plates. Explain, using principles of physics, why the acceleration of the proton is larger than that of the helium nucleus. **(4 marks)**

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 $6.0\ \Omega$ 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**

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

$= 0.508$ A ← **1 mark**

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

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

$= 1.83$ V ← **2 marks**

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

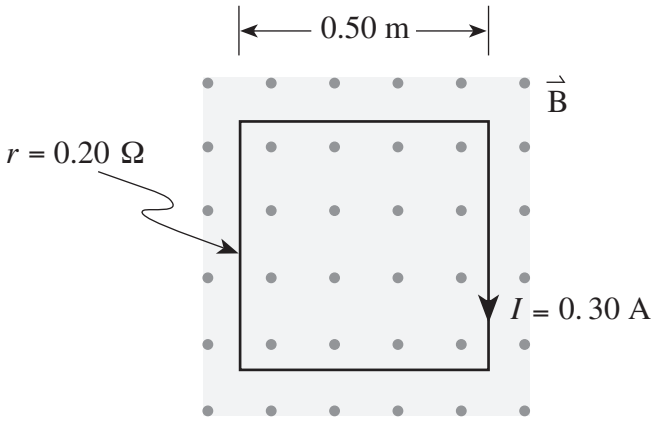
$= 0.305$ A ← **1 mark**

$E = VIt$

$= 1.83 \times 0.305 \times 15$

$= 8.4$ J ← **1 mark**

7. The single square loop of copper wire with a resistance of $0.20\ \Omega$ 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)**

$\mathcal{E} = IR$

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

$\mathcal{E} = 0.060$ V ← **2 marks**

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

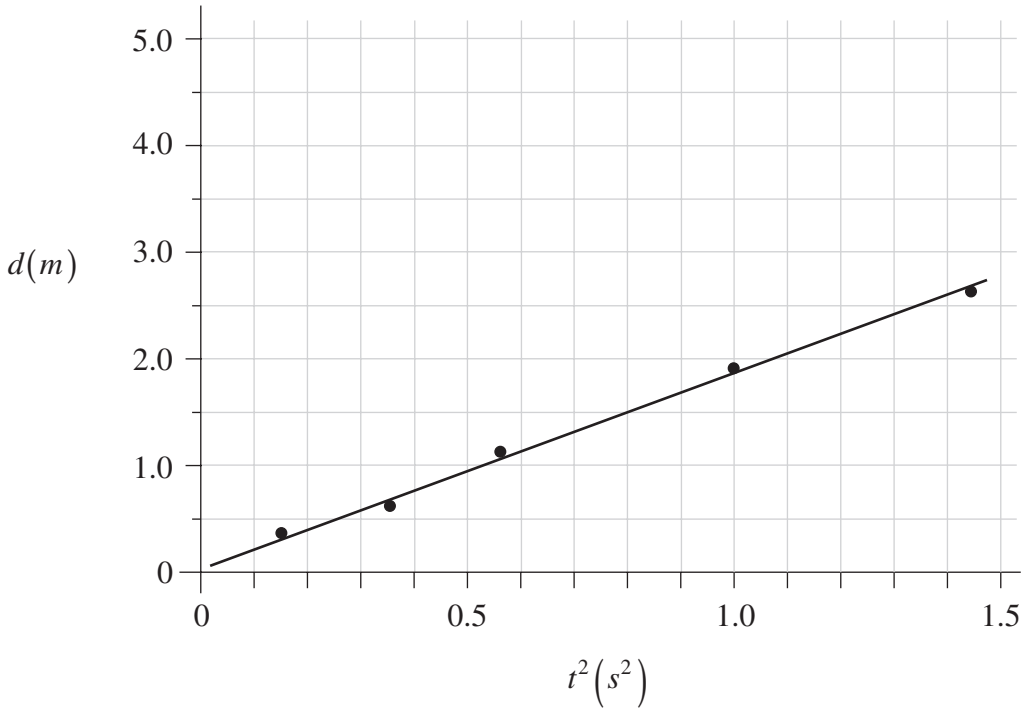
$0.060 = \dfrac{0.25(\Delta B)}{\Delta t}$ ← **1 mark**

$\dfrac{\Delta B}{\Delta t} = 0.24$ 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.

$d\ (m)$	$t\ (s)$	$t^2\left(s^2\right)$
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)



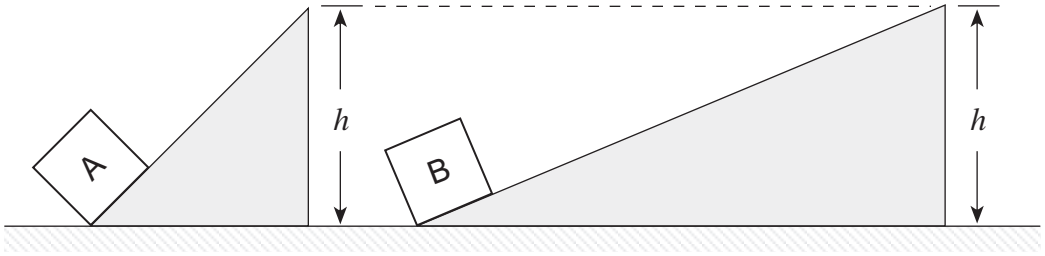
b) Determine the slope of the line. **(2 marks)**

slope $\cong 1.9$ m/s^2

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

$\cong 3.8$ 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