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.	**D E L E T E D**					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.	**D E L E T E D**					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

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

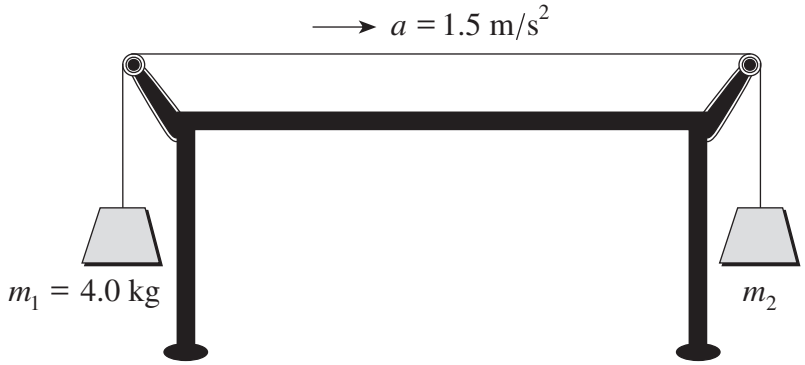
Written Response = 60 marks

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

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)**

$$F_{net} = m_s a$$

$$m_2 g - m_1 g = (m_1 + m_2)a \qquad \leftarrow \textbf{3 marks}$$

$$9.8m_2 - 9.8(4) = (4.0 + m_2)1.5$$

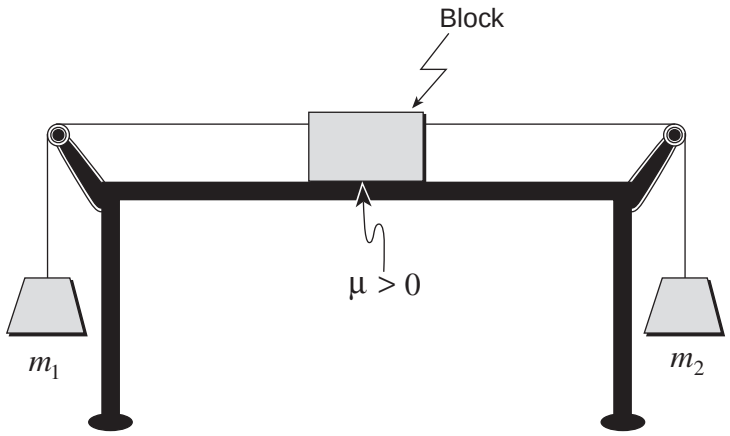
$$9.8m_2 - 39.6 = 6.0 + 1.5m_2$$

$$9.8m_2 - 1.5m_2 = 6.0 + 39.2$$

$$8.3m_2 = 45.2$$

$$m_2 = 5.4 \text{ kg} \qquad \leftarrow \textbf{2 marks}$$

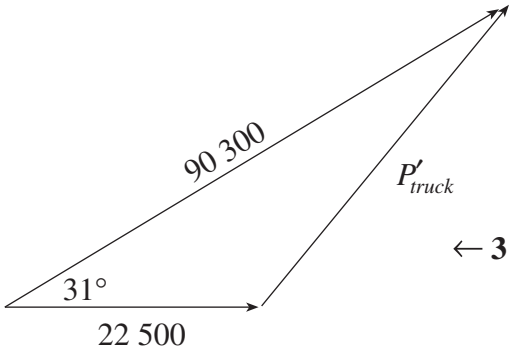
A block is then added to the system.



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)

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:

$$P'^{2}_{truck} = (22\ 500)^2 + (90\ 300)^2 - 2 \cdot 22\ 500 \cdot 90\ 300 \cdot \cos 31 \quad \leftarrow \textbf{2 marks}$$

$$P'_{truck} = 7.18 \times 10^4$$

$$\therefore v'_{truck} = \frac{7.18 \times 10^4}{4300}$$

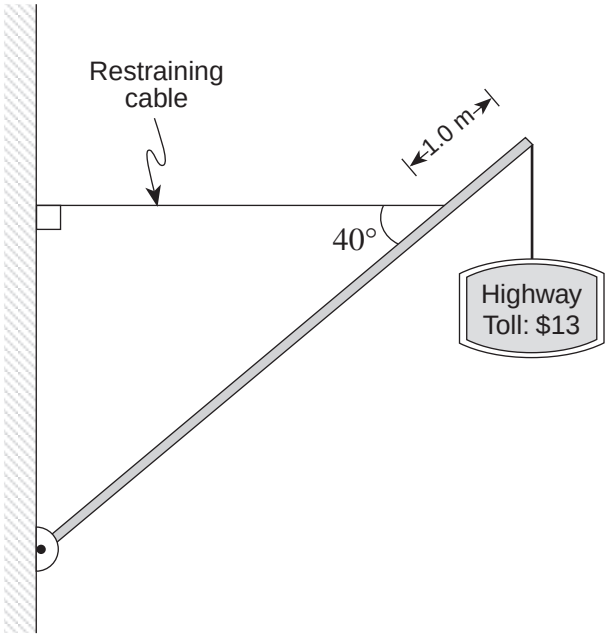
$$= 16.7$$

$$= 17 \text{ m/s}$$

← **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)



$\sum \tau_c = \sum \tau_{cc}$ ← **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**

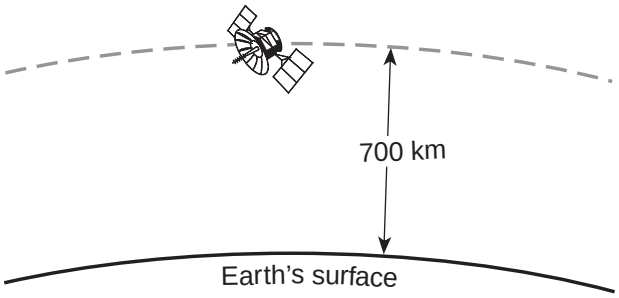
$25 \cdot 9.8 \cdot 3.0 \cdot \sin 50 + 36 \cdot 9.8 \cdot 6.0 \cdot \sin 50 = F_c \cdot 5.0 \cdot \sin 40$

$F_c = \dfrac{25 \cdot 9.8 \cdot 3.0 \cdot \sin 50 + 36 \cdot 9.8 \cdot 6.0 \cdot \sin 50}{5.0 \cdot \sin 40}$ ← **2 marks**

$= \dfrac{563.0 + 1621.6}{3.21}$

$= 680$ N ← **1 mark**

4. A 4.20×10^4 kg satellite orbits the earth at an altitude of 700 km $\left(7.00\times10^5 \text{ m}\right)$.



a) What is the satellite's orbital speed at this altitude? **(4 marks)**

$$F_g = F_c$$

$$\frac{GmM}{R^2} = \frac{mv^2}{R}$$

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

$$= \sqrt{\frac{6.67\times10^{-11}\left(5.98\times10^{24}\right)}{7.08\times10^6}}$$

$$v = 7.51\times10^3 \text{ m/s} \qquad \leftarrow \textbf{4 marks}$$

b) What is the satellite's total energy at this altitude? **(3 marks)**

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

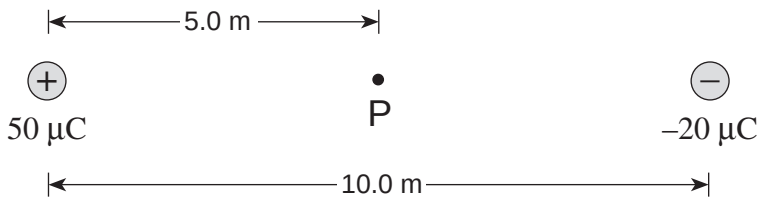
$$= \frac{-Gm_Em}{r} + \frac{1}{2}mv^2 \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{-6.67\times10^{-11}\cdot5.98\times10^{24}\cdot4.20\times10^4}{7.08\times10^6} + \frac{1}{2}\cdot4.20\times10^4\cdot\left(7.51\times10^3\right)^2$$

$$= -2.37\times10^{12} + 1.18\times10^{12}$$

$$= -1.18\times10^{12} \text{ J} \qquad \leftarrow \textbf{1 mark}$$

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**

$V = 9.0\times10^{9}\left(50\times10^{-6}\right)/5.0 \;+\; 9\times10^{9}\left(-20\times10^{-6}\right)/5.0$ ← **3 marks**

$V = 5.4\times10^{4}$ V ← **1 mark**

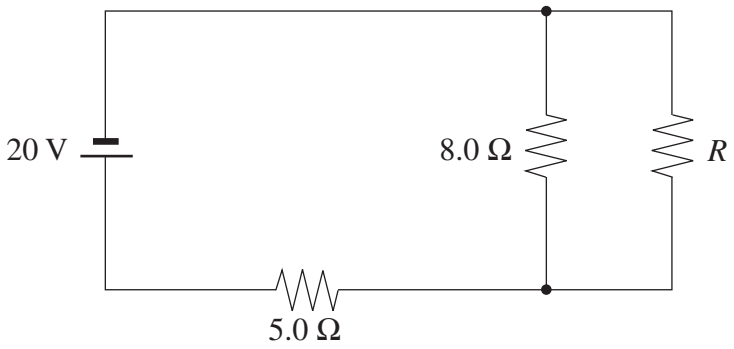
b) How much work would it take to move a -15 μC charge from point P to a position infinitely far away? **(2 marks)**

$W = \Delta E_p = E_{pf} - E_{pi}$

$W = 0 - \left(54\times10^{3}\right)\left(-15\times10^{-6}\right)$ ← **1 mark**

$W = 0.81$ J ← **1 mark**

6. The $8.0\ \Omega$ 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**

$9.0 = \left(I_{8.0\,\Omega}\right)^2 \cdot 8.0$

$I_{8.0\,\Omega} = 1.06\ A$ ← **1 mark**

$V_R = V_{8.0\,\Omega} = 1.06 \cdot 8.0 = 8.48\ V$ ← **1 mark**

$I_R = I_{circuit} - I_{8.0\,\Omega}$

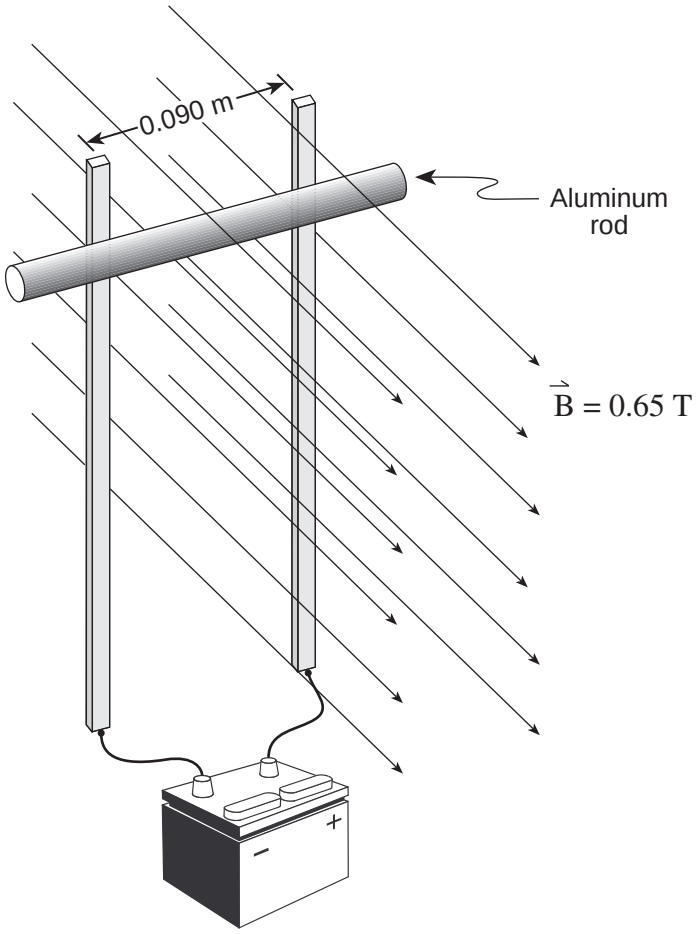
$I_R = \left(20 - 8.48\right)/\left(5.0\right) - 1.06$

$= 1.24\ A$ ← **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)**

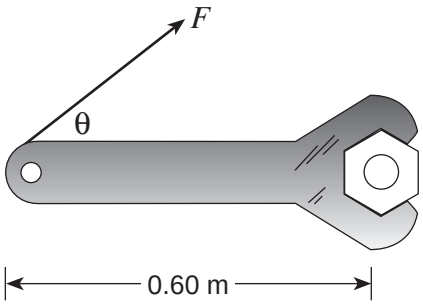
$\vec{F}_g = \vec{F}_B$ ← **2 marks**

$mg = BI\ell$ ← **2 marks**

$= \dfrac{0.13 \times 9.8}{0.65 \times 0.090}$ ← **2 marks**

$= 22\ A$ ← **1 mark**

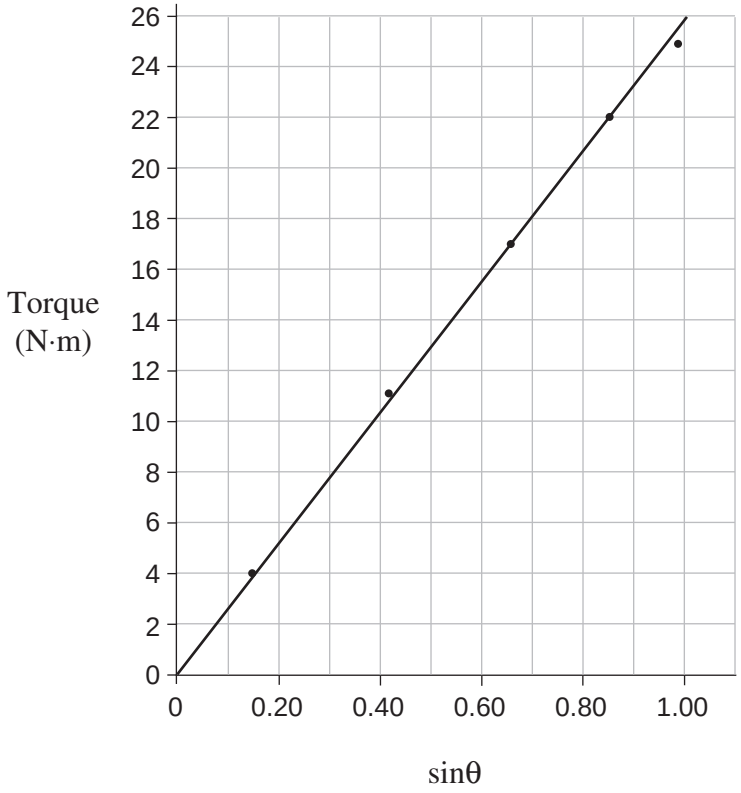
8. A student uses a wrench to apply a constant force to turn a nut. He applies the force at various angles and measures the amount of torque produced at each of the angles.



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 $\approx 25\ \text{N} \cdot \text{m}$ $\leftarrow$ **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)**

$$\tau = F \cdot \ell$$

$$F = \frac{\text{slope}}{\ell} = \frac{\tau}{\ell} = \frac{25\ \text{N} \cdot \text{m}}{0.60} \approx 42\ \text{N}$$

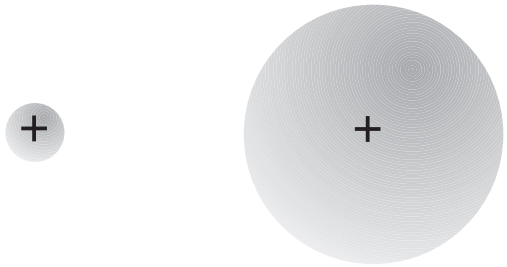
$\leftarrow$ **2 marks**

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)

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