Physics 12

June 2001 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.	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

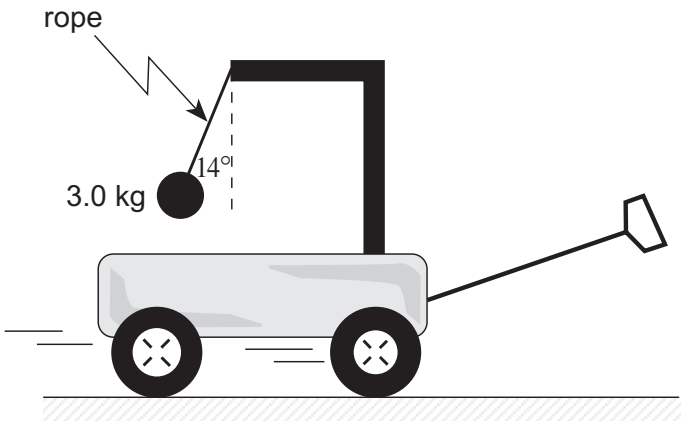
Written Response = 60 marks

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

LEGEND:

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

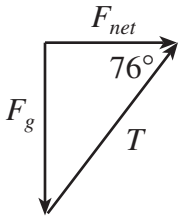
1. A 3.0 kg mass hangs at one end of a rope that is attached to a support on a child's wagon as shown in the diagram. The wagon is pulled to the right. (You may ignore air resistance.)



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)**



$$\tan 76° = \frac{F_g}{F_{net}}$$

$$F_{net} = \frac{F_g}{\tan 76°}$$

$$= \frac{3.0 \times 9.8}{\tan 76°}$$

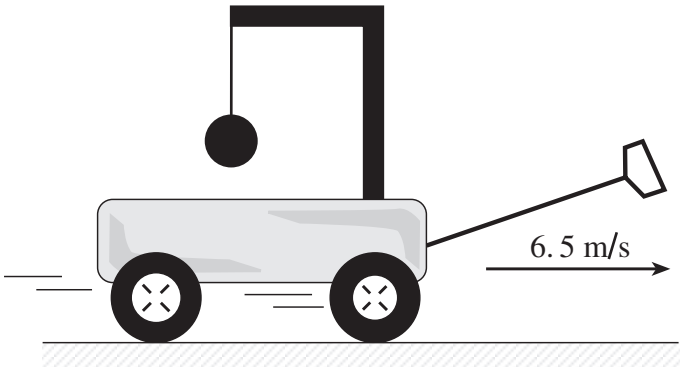
$$= 7.33 \text{ N} \qquad \leftarrow \textbf{2 marks}$$

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

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

$$a = 2.4 \text{ m/s}^2 \qquad \leftarrow \textbf{1 mark}$$

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)**

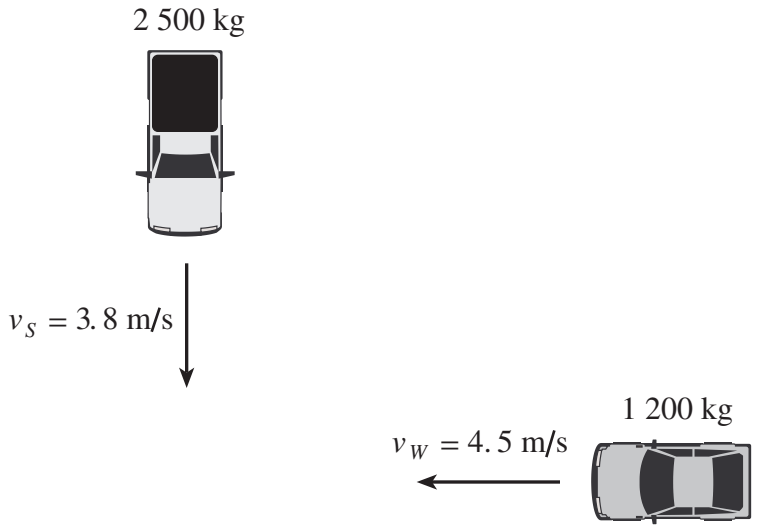
$\therefore F_{net} = 0$ **(1 mark)**

$\therefore$ Sum of all vertical forces is zero

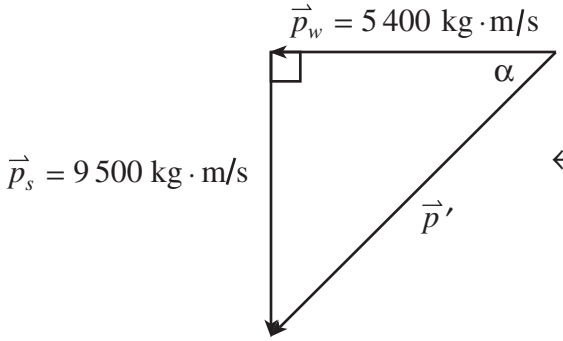
$\therefore$ Tension $= F_g$ **($\frac{1}{2}$ mark)**

$\therefore$ 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**

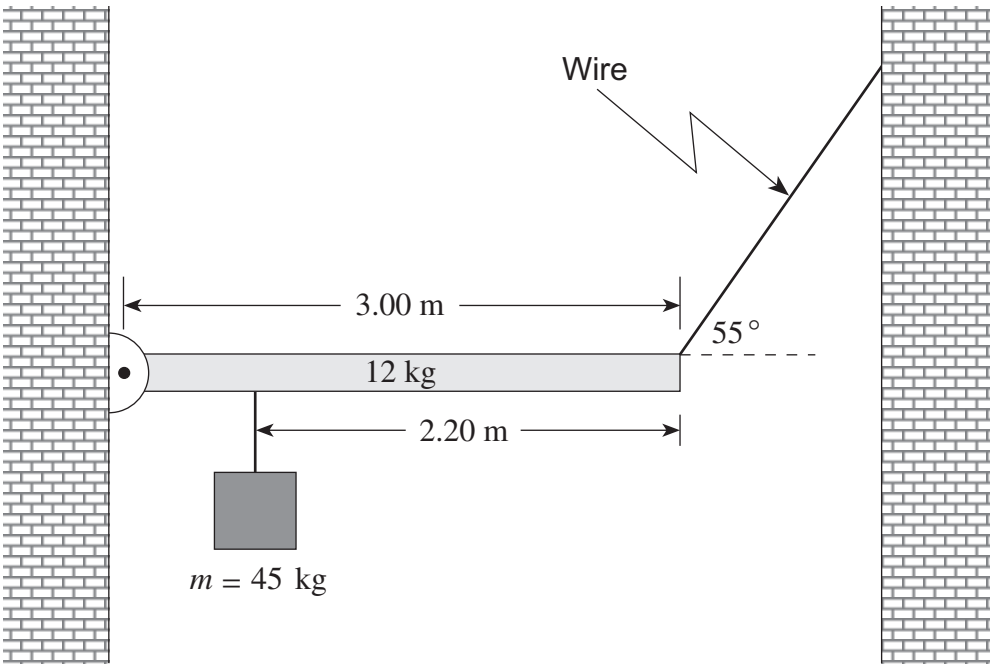
$v' = \dfrac{10\,900}{(2\,500 + 1\,200)} = 3.0$ m/s ← **1 mark for dividing by 3700**

$\tan\alpha = \dfrac{9\,500}{5\,400}$

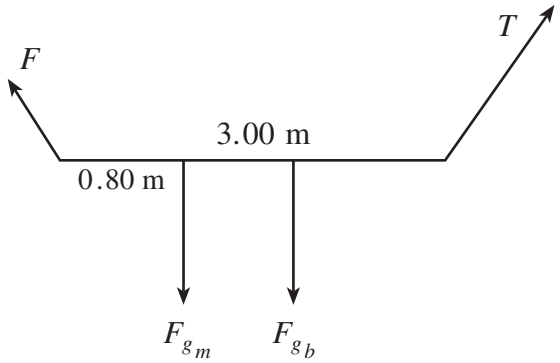
$\alpha = 60°$ ← **1 mark**

$v' = 3.0$ 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)**



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

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

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

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

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

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)**

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

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

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

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

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

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

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

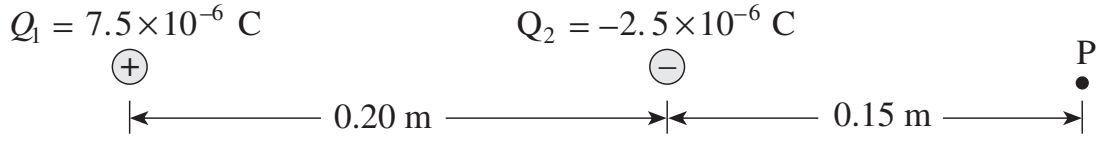
c) What is the total energy of the satellite? **(2 marks)**

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

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

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

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)**

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

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

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

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

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

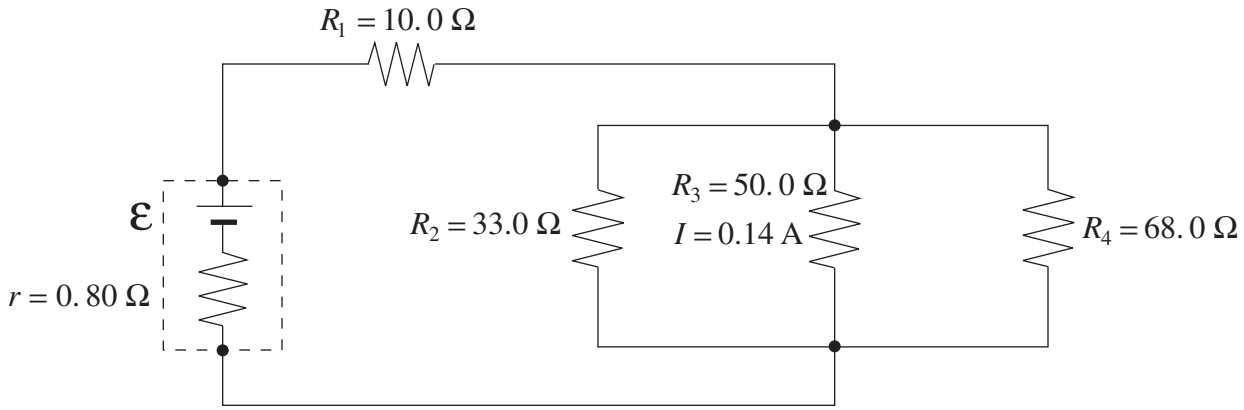
$$= -1.50\times10^5\text{ V} \qquad \leftarrow \textbf{2 marks}$$

$$V_p = V_1 + V_2$$

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

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

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)**

$$V_{||} = I \cdot R$$
$$= I_3 \cdot R_3$$
$$= 0.14 \cdot 50.0$$
$$= 7.0 \text{ V} \quad \leftarrow \textbf{1 mark}$$

$$\therefore I_2 = \frac{V_{||}}{R_2}$$
$$= \frac{7.0}{33.0}$$
$$= 0.21 \text{ A} \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$I_4 = \frac{V_{||}}{R_4}$$
$$= \frac{7.0}{68.0}$$
$$= 0.10 \text{ A} \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$\therefore I_{||} = I_2 + I_3 + I_4$$
$$= 0.21 + 0.14 + 0.10$$
$$= 0.45 \text{ A} \quad \leftarrow \textbf{1 mark}$$

$$R_{||} = \frac{1}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$$
$$= 15.4\ \Omega \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$R_T = R_1 + R_{||} + r$$
$$= 10.0 + 15.4 + 0.80$$
$$= 26.2\ \Omega \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$\therefore \mathcal{E} = I \cdot R_T$$
$$= 0.45 \cdot 26.2$$
$$= 11.9 \text{ V}$$
$$= 12 \text{ V} \quad \leftarrow \textbf{1 mark}$$

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**

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)**

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

$$B = \frac{\left(4\pi\times10^{-7}\right)(820)(5.3)}{(0.16)} \qquad \leftarrow \textbf{1 mark}$$

$$B = 3.4\times10^{-2}\ \text{T} \qquad \leftarrow \textbf{1 mark}$$

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

$$F_c = \frac{mv^2}{r} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$F_E = Bqv \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

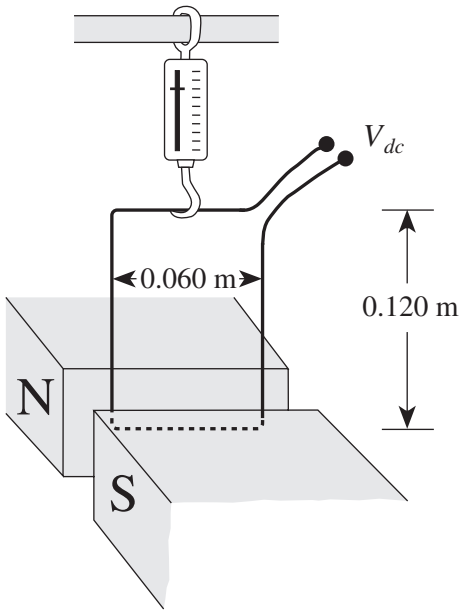
$$Bqv = \frac{mv^2}{r}$$

$$r = \frac{mv}{Bq} \qquad \leftarrow \textbf{1 mark}$$

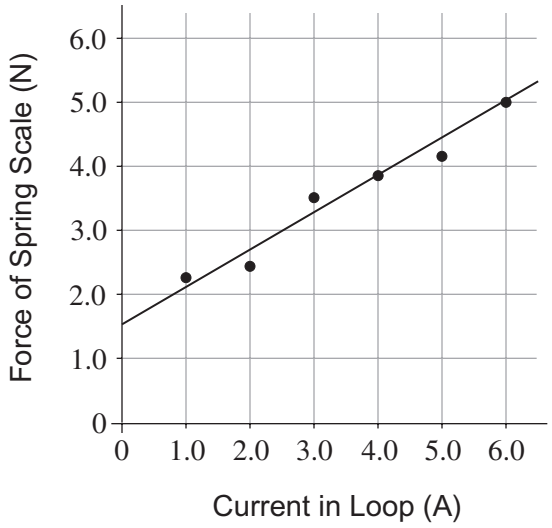
$$r = \frac{\left(1.67\times10^{-27}\right)\left(2.2\times10^{5}\right)}{\left(3.4\times10^{-2}\right)\left(1.6\times10^{-19}\right)} \qquad \leftarrow \textbf{1 mark}$$

$$r = 6.8\times10^{-2}\ \text{m} \qquad \leftarrow \textbf{1 mark}$$

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 $B\ell$ ← **1 mark**

$\therefore 0.58 = B(0.060)$ ← **½ mark**

$B = 9.7\ \text{T}$ ← **½ 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