Physics 12

January 1998 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	A2	16.	A	K	4	J3
2.	C	K	1	C6	17.	C	U	4	J9
3.	A	U	1	B7, B8	18.	A	K	5	L7
4.	A	U	1	C3, 4, 7, 8	19.	A	U	5	L6, 5
5.	B	U	1	C4	20.	A	H	5	L5
6.	B	K	2	E9	21.	A	K	6	N4
7.	C	U	2	E5, 7, F7	22.	B	U	6	M11
8.	B	U	2	F4	23.	B	H	6	N2, M11
9.	A	K	3	H1	24.	B	K	7	O9
10.	D	U	3	H3	25.	D	U	7	O4
11.	C	U	3	H8	26.	C	U	7	O3, 8
12.	D	K	4	I3	27.	D	U	7	P1
13.	D	U	4	H2, I5	28.	C	U	7	P9
14.	C	U	4	I4, C7	29.	A	U	7	P12
15.	A	U	4	I4	30.	A	H	7	P5, 6

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	CO	S	PLO
1.	1	U	1	7	D5
2.	2	U	2	7	G1, 3
3.	3	U	3	7	H3
4.	4	U	4	9	J8, 9, 2
5.	5	U	5	7	K5
6.	6	U	6	7	M6, 2, 7
7.	7	U	7	7	O6, L6
8	8	H	1	5	A10
9.	9	H	2	4	E8

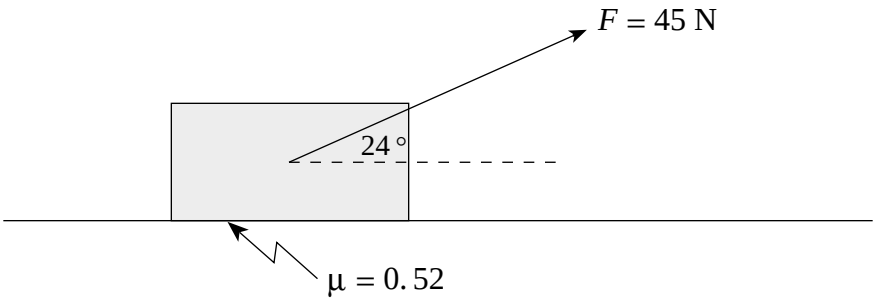
Written Response = 60 marks

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 student drags a 7.0 kg carton of apples across the floor by exerting a 45 N force in the direction shown. The coefficient of friction between the carton and the floor is 0.52.



a) What is the magnitude of the normal force acting on the carton? **(2 marks)**

$F_N + F\sin 24° = F_g$ ← **1 mark**

$F_N + 18.3\text{ N} = 68.6\text{ N}$ ← **½ mark**

$F_N = 50.3\text{ N}$ ← **½ mark**

b) What friction force acts on the carton? **(2 marks)**

$F_f = \mu F_N$ ← **1 mark**

$= 0.52(50.3)\text{ N}$ ← **½ mark**

$= 26.2\text{ N}$ ← **½ mark**

c) What is the acceleration of the carton? **(3 marks)**

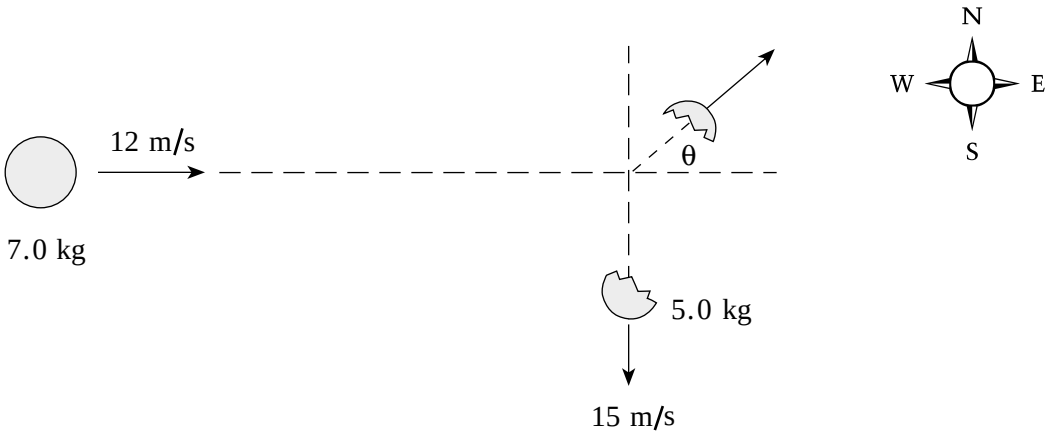
$F_{net} = ma$ ← **½ mark**

$F\cos 24° - F_f = ma$ ← **1 mark**

$41.1\text{ N} - 26.2\text{ N} = 7.0a$ ← **1 mark**

$a = 2.1\text{ m/s}^2$ ← **½ mark**

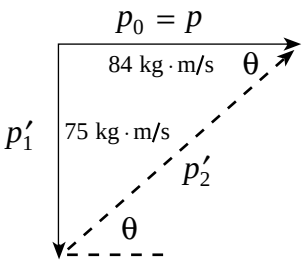
2. A 7.0 kg object moving at 12 m/s to the east explodes into two unequal fragments. The larger 5.0 kg fragment moves at 15 m/s south.



What is the velocity (speed and direction) of the smaller 2.0 kg fragment? **(7 marks)**

$p_0 = p$

$p_0 = m_0 v_0 = 7.0(12) = 84 \text{ kg} \cdot \text{m/s}$ } ← **1 mark for isolation**



$p_2' = (p_1')^2 + (p_0')^2$

$= 75^2 \text{ kg} \cdot \text{m/s}^2 + 84^2 \text{ kg} \cdot \text{m/s}^2$ ← **3 marks**

$p_2' = 113 \text{ kg} \cdot \text{m/s}$ ← **1 mark**

$v_2' = \dfrac{p_2'}{m_2} = \dfrac{113}{2.0} = 56 \text{ m/s}$ ← **1 mark**

$\dfrac{\sin\theta}{75} = \dfrac{\sin 90}{113} \quad \therefore \theta = 42° \text{ N of E}$

$\tan\theta = \dfrac{75}{84} \quad \therefore \theta = 42° \text{ N of E}$ } ← **either one for 1 mark**

Component Method:

x: $m_0 v_{0x} = m_1 v_{1x}' + m_2 v_{2x}'$

$$(7\text{ kg})(12\text{ m/s}) = (5\text{ kg})(0\text{ m/s}) + (2\text{ kg})\left(v_{2x}'\right)$$

$$v_{2x}' = 42\text{ m/s} \qquad \leftarrow \textbf{2 marks}$$

y: $m_0 v_{0y} = m_1 v_{1y}' + m_2 v_{2y}'$

$$(7\text{ kg})(0\text{ m/s}) = (5\text{ kg})(-15\text{ m/s}) + (2\text{ kg})\left(v_{2y}'\right)$$

$$v_{2y}' = 37.5\text{ m/s} \qquad \leftarrow \textbf{2 marks}$$

$$\left(v_2'\right)^2 = \left(v_{2x}'\right)^2 + \left(v_{2y}'\right)^2$$

$$= (42\text{ m/s})^2 + (37.5\text{ m/s})^2$$

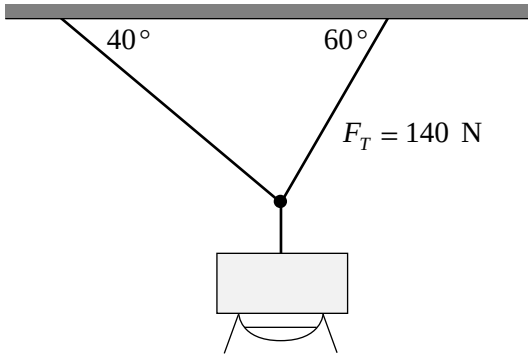
$$v_2' = 56.3\text{ m/s} \qquad \leftarrow \textbf{2 marks}$$

$$\tan\theta = \frac{v_{2y}'}{v_{2x}'}$$

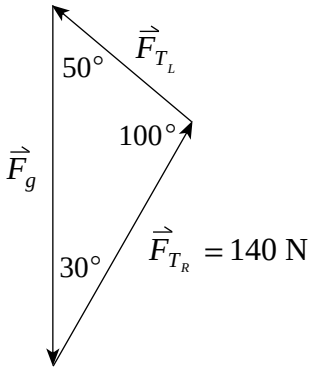
$$= \frac{37.5\text{ m/s}}{42\text{ m/s}}$$

$$\theta = 42^\circ\text{ N of E} \qquad \leftarrow \textbf{1 mark}$$

3. A floodlight is suspended from two cables as shown below. The tension in the right cable is 140 N.



a) What is the tension in the left cable? **(3 marks)**



$$\frac{\sin 50°}{140\ \text{N}} = \frac{\sin 30°}{F_{T_L}} \quad \leftarrow \textbf{2 marks}$$

$$F_{T_L} = 91.4\ \text{N} \quad \leftarrow \textbf{1 mark}$$

b) What is the mass of the floodlight? **(4 marks)**

$$\frac{\sin 50°}{140\ \text{N}} = \frac{\sin 100°}{F_g} \quad \leftarrow \textbf{2 marks}$$

$$F_g = 180\ \text{N} \quad \leftarrow \textbf{1 mark}$$

$$m = 18.4\ \text{kg} \quad \leftarrow \textbf{1 mark}$$

4. A 1 200 kg space probe is in a circular orbit around the Sun. The orbital radius is 7.0×10^9 m.

a) What is the orbital speed of this satellite? **(5 marks)**

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

$$\frac{Gm_1m_2}{r^2} = \frac{m_1v^2}{r} \qquad \leftarrow \textbf{2 marks}$$

$$v^2 = \frac{Gm}{r}$$

$$v^2 = \frac{\left(6.67 \times 10^{-11}\ \text{N} \cdot \text{m}^2/\text{kg}^2\right)\left(1.98 \times 10^{30}\ \text{kg}\right)}{7.0 \times 10^9\ \text{m}} \qquad \leftarrow \textbf{1 mark}$$

$$v = 1.37 \times 10^5\ \text{m/s} \qquad \leftarrow \textbf{1 mark}$$

b) If the Sun collapsed to one-tenth its present radius without a change to its mass, the space probe's orbital radius will

- ☐ increase.
- ☐ decrease.
- ☑ stay the same.

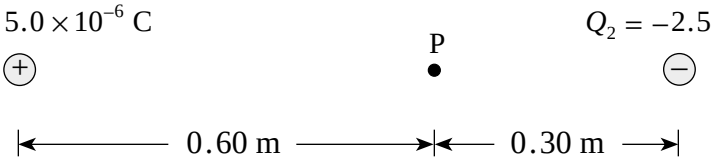
(Check one response.) **(1 mark)**

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

Since the mass of the sun has not changed and the distance between the two objects has not changed, then the force of gravity is still the same. The force of gravity is the net force; therefore the centripetal force must be the same.

5. Calculate the net electric field (magnitude and direction) at point P due to the two point charges shown in the diagram.

(7 marks)



$$\vec{E}_p = \vec{E}_1 + \vec{E}_2$$

$$E_1 = \frac{kQ_1}{r_1^2}$$

$$= \frac{9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \cdot 5.0 \times 10^{-6} \text{ C}}{(0.60 \text{ m})^2}$$

$$= 1.25 \times 10^5 \text{ N/C} \quad (\text{right}) \qquad \leftarrow \textbf{2 marks}$$

$$E_2 = \frac{kQ_2}{r_2^2}$$

$$= \frac{9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \cdot 2.5 \times 10^{-6} \text{ C}}{(0.30 \text{ m})^2}$$

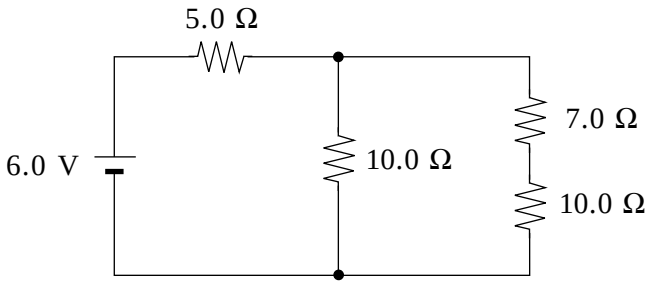
$$= 2.50 \times 10^5 \text{ N/C} \quad (\text{right}) \qquad \leftarrow \textbf{2 marks}$$

$$\therefore E_p = 1.25 \times 10^5 \text{ N/C} + 2.50 \times 10^5 \text{ N/C} \quad \leftarrow \textbf{1 mark}$$

$$= 3.75 \times 10^5 \text{ N/C}$$

$$= 3.8 \times 10^5 \text{ N/C} \quad (\text{right}) \quad \leftarrow \textbf{2 marks}$$

6. Consider the circuit shown below.



a) What is the current through the $7.0\ \Omega$ resistor? **(5 marks)**

$$\frac{1}{R_{||}} = \frac{1}{10.0\ \Omega} + \frac{1}{(10.0+7.0)\ \Omega}$$

$R_{||} = 6.30\ \Omega$ ← **½ mark**

$R_T = 5.0\ \Omega + 6.30\ \Omega$

$= 11.3\ \Omega$ ← **½ mark**

$I_T = \dfrac{V}{R_T}$

$= \dfrac{6.0\ \text{V}}{11.3\ \Omega}$

$= 0.53\ \text{A}$ ← **1 mark**

$V_{||} = I_T \cdot R_{||}$

$= 0.53\ \text{A} \cdot 6.3\ \Omega$

$= 3.34\ \text{V}$ ← **1 mark**

$\therefore I_7 = \dfrac{V_{||}}{(10.0+7.0)\ \Omega}$

$= \dfrac{3.34\ \text{V}}{17.0\ \Omega}$ ← **1 mark**

$= 0.20\ \text{A}$ ← **1 mark**

b) How much charge flows through the $7.0\ \Omega$ resistor in a $30\ \text{s}$ interval? **(2 marks)**

$Q = I \cdot t$

$= 0.20\ \text{A} \cdot 30\ \text{s}$

$= 6.0\ \text{C}$ ← **2 marks**

7. An electron is accelerated from rest through a potential difference of 750 V. It then enters a uniform 2.3×10^{-3} T magnetic field at right angles to the field.

a) What is the speed of the electron? **(3 marks)**

$$\Delta E_p = E_k$$

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

$$\left(1.60\times10^{-19}\text{ C}\right)\left(750\text{ V}\right) = \frac{1}{2}\left(9.11\times10^{-31}\text{ kg}\right)v^2 \qquad \leftarrow \textbf{1}\ \tfrac{1}{2}\ \textbf{mark}$$

$$v = 1.62\times10^{7}\text{ m/s} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark (for answer)}$$

b) What is the radius of its path in the magnetic field? **(4 marks)**

$$F_C = F_B \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

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

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

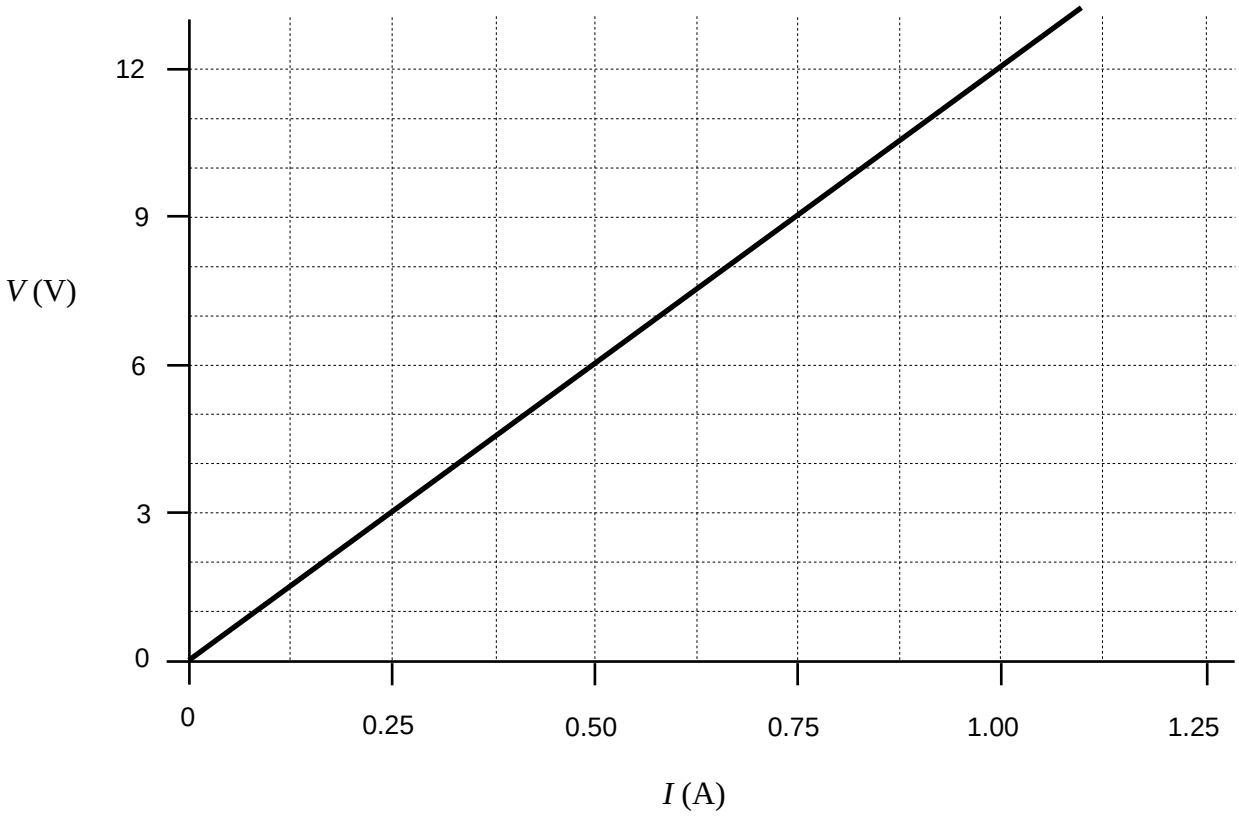
$$r = \frac{\left(9.11\times10^{-31}\text{ kg}\right)\left(1.62\times10^{7}\text{ m/s}\right)}{\left(1.60\times10^{-19}\text{ C}\right)\left(2.3\times10^{-3}\text{ T}\right)} \qquad \leftarrow \textbf{1 mark}$$

$$r = 4.0\times10^{-2}\text{ m} \qquad \leftarrow \textbf{1 mark}$$

8. A student connects a power supply to a circuit and measures the potential difference V at its terminals and the current I delivered to the circuit.

V (V)	0.0	3.0	6.0	9.0	12.0
I (A)	0.00	0.25	0.50	0.75	1.00

a) Plot a graph of V versus I on the axes below. **(2 marks)**



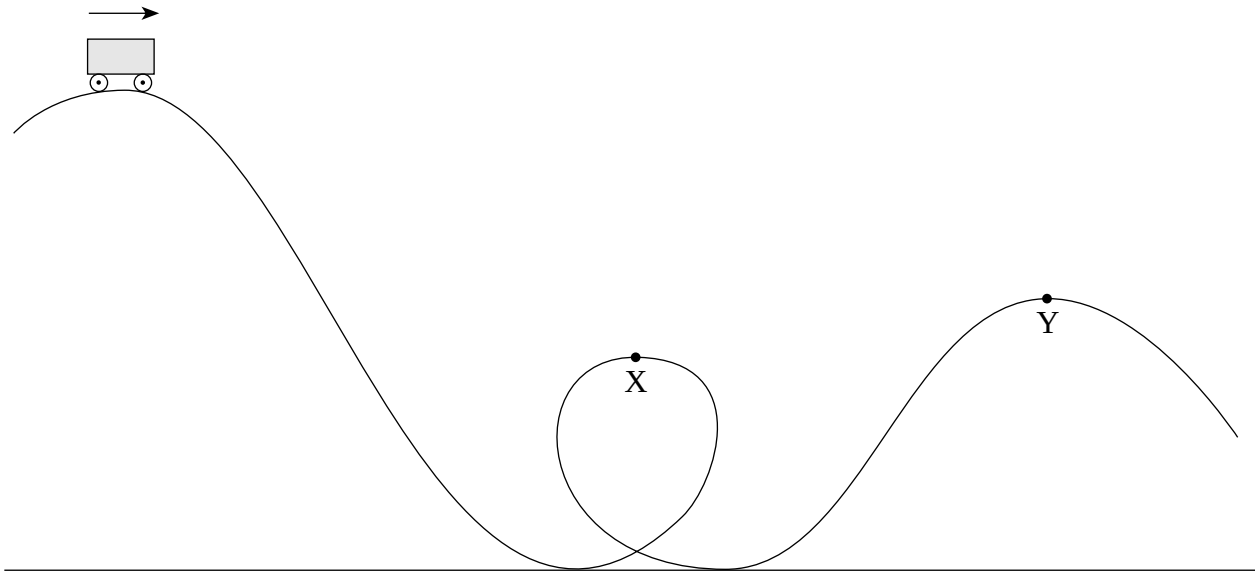
b) Calculate the slope of the line, expressing your answer in appropriate units. **(2 marks)**

$$slope = \frac{\Delta V}{\Delta I} = 12 \text{ V/A}$$ ← **1 mark**; **units 1 mark**

c) What does the slope of the line represent? **(1 mark)**

The slope represents the resistance of the circuit. ← **1 mark**

9. A roller coaster car is released from the crest of a hill.



a) How does the speed at Y compare to the speed at X? Ignore friction. (Check one response.) **(1 mark)**

- ☐ The speed at Y is equal to the speed at X.
- ☑ The speed at Y is less than the speed at X.
- ☐ The speed at Y is greater than the speed at X.

b) Explain your answer using principles of physics. **(3 marks)**

Point Y is at a higher location than X. ($\frac{1}{2}$ mark)
The potential energy at Y is greater than the potential energy at X. (1 mark)
Since total energy is constant (1 mark), the kinetic energy at Y is less than the kinetic energy at X. ($\frac{1}{2}$ mark)

END OF KEY