Physics 12

January 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.	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

PART B: Written Response

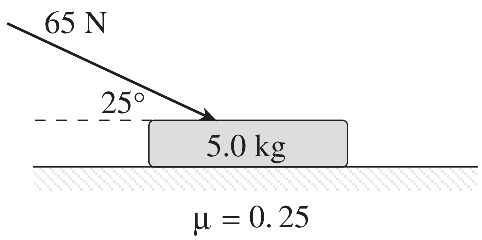
Q	B	C	S	CO	PLO
1.	1	U	7	1	D4; C8
2.	2	H	9	2	E7, 8; B2
3.	3	U	7	3	H11, 5
4.	4	U	7	4	J7, 9, 10
5.	5	U	7	5	L2; E10
6.	6	U	7	6	M5, 6, 7
7.	7	U	7	7	O6; C4
8	8	H	5	1	A10; P9
9.	9	H	4	2	F4; A10

Written Response = 60 marks

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

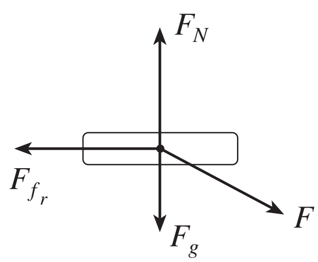
LEGEND:
Q = Question Number **B** = Score Box Number **C** = Cognitive Level
CO = Curriculum Organizer **K** = Keyed Response **S** = Score
PLO = Prescribed Learning Outcome

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



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**

$$= F_x - \mu F_N$$

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

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

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

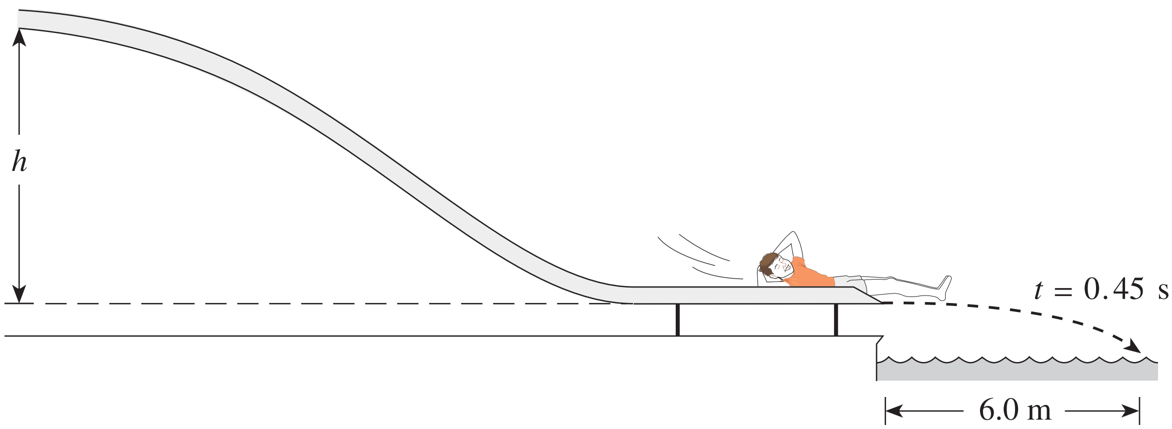
$$= 58.9 - 19.1$$

$$= 39.8 \text{ N}$$

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

$$= 8.0 \text{ m/s}^2$$ ← **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)**

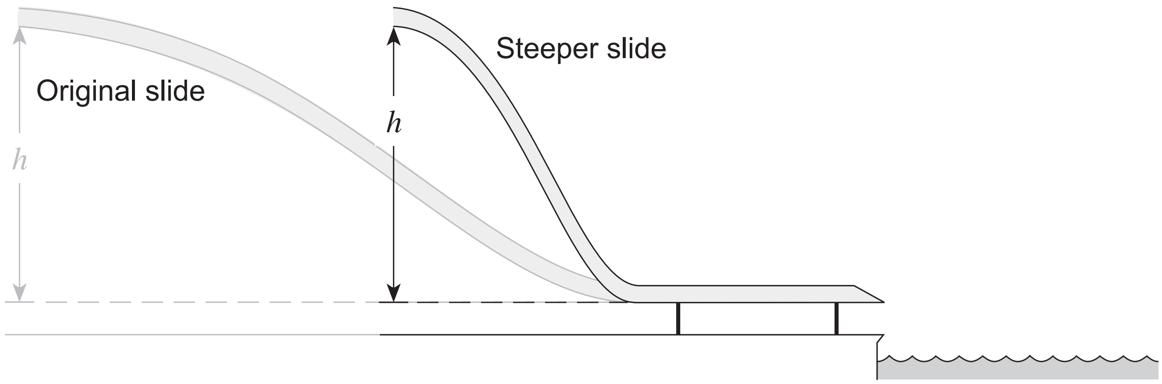
$$v = \frac{d}{t} = \frac{6.0}{0.45} = 13.3 \text{ m/s}$$ ← **1 mark**

$$E_k = E_p$$ ← **1 mark**

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

$$h = \frac{v^2}{2g} = \frac{13.3^2}{2 \times 9.8} = 9.1 \text{ m}$$ ← **1 mark**

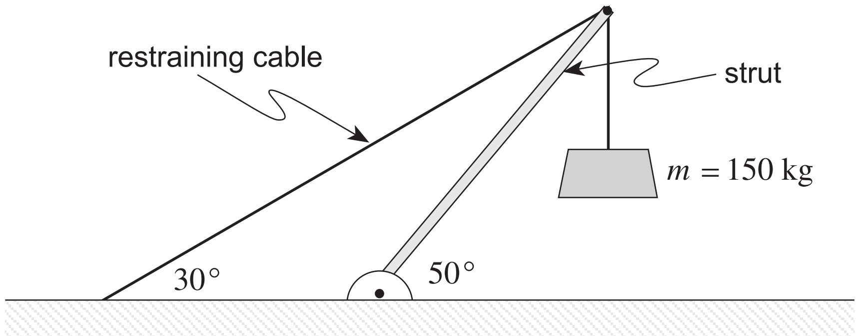
b) Another slide has the same vertical height, h, as the original slide, but has a much steeper slide angle.



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 $\left(E_p = E_k\right)$ 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**

$T\sin 20 \cdot \not{l} = W\sin 40 \cdot \not{l} + F_g \sin 40 \cdot \frac{\not{l}}{\not{2}}$ ← **3 marks**

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

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

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

$= 3\ 545 \text{ N}$

$= 3.5 \times 10^3 \text{ N}$ ← **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)**

$$E_{orbit} = \frac{1}{2}E_p$$

$$= \frac{1}{2}\left(-\frac{GmM}{R}\right)$$

$$= \frac{1}{2}\left(-\frac{6.67\times10^{-11}\left(3.5\times10^{3}\right)\left(5.98\times10^{24}\right)}{6.88\times10^{6}}\right)$$

$$= -1.01\times10^{11}\ \text{J}$$ ← **4 marks**

$$E_{surface} = -\frac{GmM}{R}$$

$$= -\frac{6.67\times10^{-11}\left(3.5\times10^{3}\right)\left(5.98\times10^{24}\right)}{6.38\times10^{6}}$$

$$= -2.19\times10^{11}\ \text{J}$$ ← **1 mark**

$$\Delta E = E_{orbit} - E_{surface}$$ ← **1 mark**

$$= \left(-1.01\times10^{11}\right)-\left(-2.19\times10^{11}\right)$$

$$= 1.17\times10^{11}\ \text{J}$$

$$= 1.2\times10^{11}\ \text{J}$$ ← **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)**

$E = P \times t$ ← **½ mark**

$= 65 \times 1.5 \times 3\,600$ ← **1 mark**

$= 3.5 \times 10^{5}$ J ← **½ mark**

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

$Q = \frac{\Delta E}{V}$ ← **½ mark**

$= \frac{3.5 \times 10^{5}\text{ J}}{12\text{ V}}$ ← **2 marks**

$= 29\,000$ C ← **½ mark**

OR

$Q = It$ ← **½ mark**

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

$= 29\,000$ C ← **½ mark**

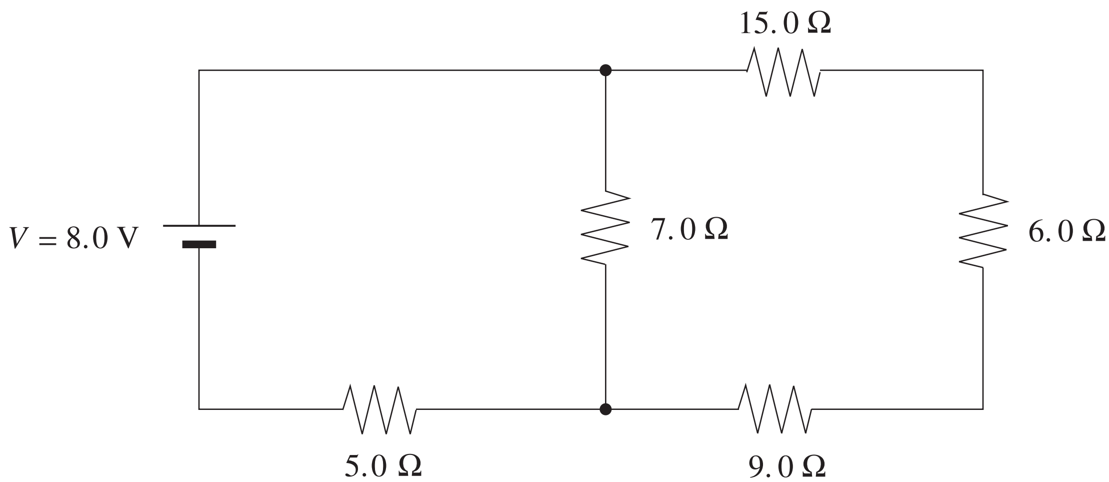
c) What is the total number of electrons that pass through the headlight during this time period? **(2 marks)**

$N = \frac{Q}{e}$ ← **1 mark**

$= \frac{29\,000}{1.6 \times 10^{-19}\text{ C}}$ ← **1 mark**

$= 1.8 \times 10^{23}$ electrons

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**

$\text{V}_6 = I_p R$

$= 0.142 \times 6.0$

$= 0.85\ \text{V}$ ← **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**

$= \frac{(1.6 \times 10^{9})(2\,200)(15)}{1.67 \times 10^{-27}}$ m/s^2 ← **½ mark**

$= 3.2 \times 10^{10}$ 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**

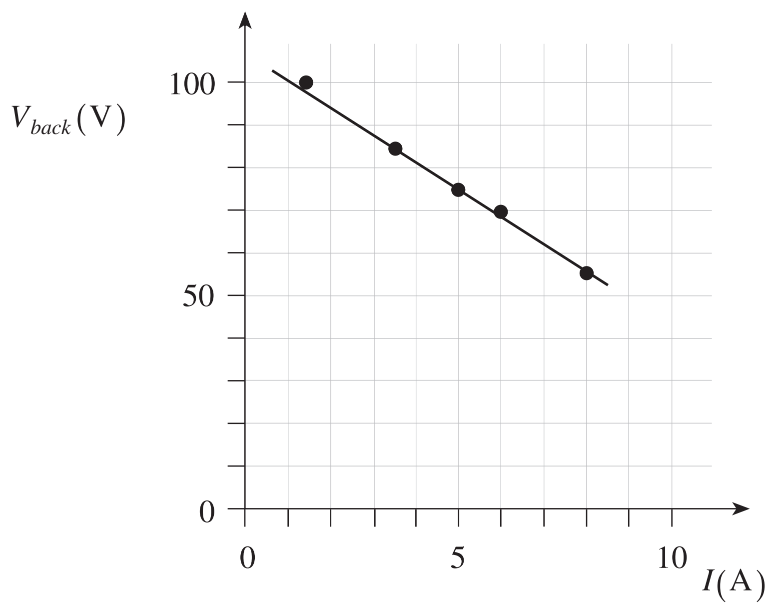
$= \frac{(2\,200)^2}{3.2 \times 10^{10}}$ m ← **½ mark**

$= 1.5 \times 10^{-4}$ 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)

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

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

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

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

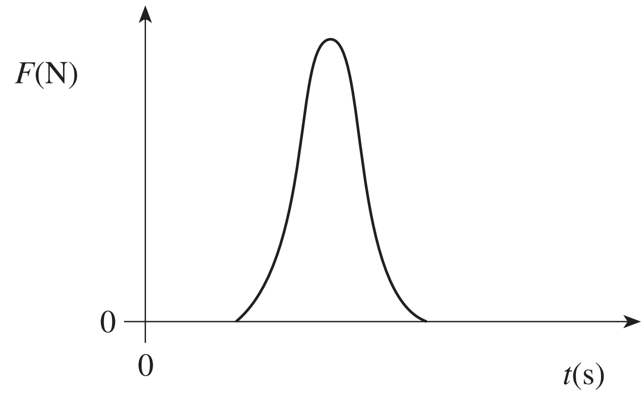
resistance (or internal resistance ok) ← 2 marks

“decreasing resistance”: –1

“change in resistance”: –1

“emf + / – resistance”: –1 $\tfrac{1}{2}$

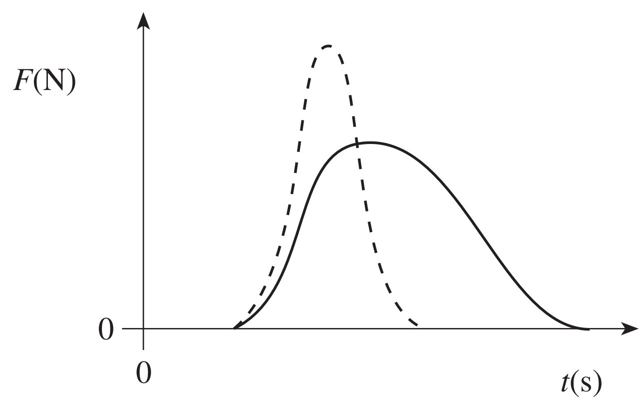
9. In sports such as golf, tennis and baseball, a player exerts a force over a time interval on a ball in order to give it a high speed, as shown on the graph.



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