Physics 12

June 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.	C	K	1	B3	16.	A	U	4	J7, E5
2.	B	U	1	A6, B7	17.	C	H	4	J9
3.	D	U	1	B2	18.	D	K	5	K6
4.	B	K	1	C5, 7	19.	D	U	5	K3
5.	A	U	1	C3, 7, 8	20.	D	U	5	K5
6.	C	U	2	E3	21.	D	K	6	M9
7.	B	K	2	F1	22.	B	U	6	N2
8.	B	U	2	F7	23.	B	K	7	P2
9.	C	K	3	H5	24.	A	U	7	O4
10.	C	U	3	H11	25.	C	U	7	O7
11.	D	H	3	H3, C7, 8	26.	D	U	7	O8
12.	B	K	4	J1	27.	C	U	7	P1
13.	A	U	4	J2, I4	28.	B	U	7	P9
14.	D	U	4	J9	29.	A	U	7	P11
15.	B	U	4	J10	30.	D	H	7	O6, E7, I4

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	CO	S	PLO
1.	1	U	1	7	D5 or C3
2.	2	U	2	7	E7
3.	3	U	3	7	H11
4.	4	U	4	7	I14, C3, 7
5.	5	U	5	7	L8
6.	6	U	6	9	M11, N2
7.	7	U	7	7	P5, M5
8.	8	H	1	5	A10
9.	9	H	2	4	F4, G2

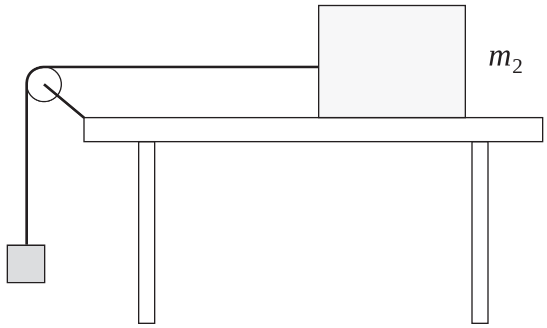
Written Response = 60 marks

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. The diagram shows two objects connected by a light string over a frictionless pulley. Object m_2 is on a frictionless horizontal table. The tension in the string is 24 N.



a) Find the acceleration of the system. **(4 marks)**

$$F_{g_1} - F_T = m_1 a \qquad \leftarrow \textbf{1 mark}$$

$$3.0\ \text{kg} \cdot 9.8\ \text{m/s}^2 - 24\ \text{N} = 3.0\ \text{kg} \cdot a \qquad \leftarrow \textbf{2 marks}$$

$$29.4\ \text{N} - 24\ \text{N} = 3.0\ \text{kg} \cdot a$$

$$a = 1.8\ \text{m/s}^2 \qquad \leftarrow \textbf{1 mark}$$

b) Find the mass of m_2. **(3 marks)**

$$F_T = m_2 a \qquad \leftarrow \textbf{1 mark}$$

$$24\ \text{N} = m_2 \cdot 1.8\ \text{m/s}^2 \qquad \leftarrow \textbf{1 mark}$$

$$m_2 = 13.3\ \text{kg} \qquad \leftarrow \textbf{1 mark}$$

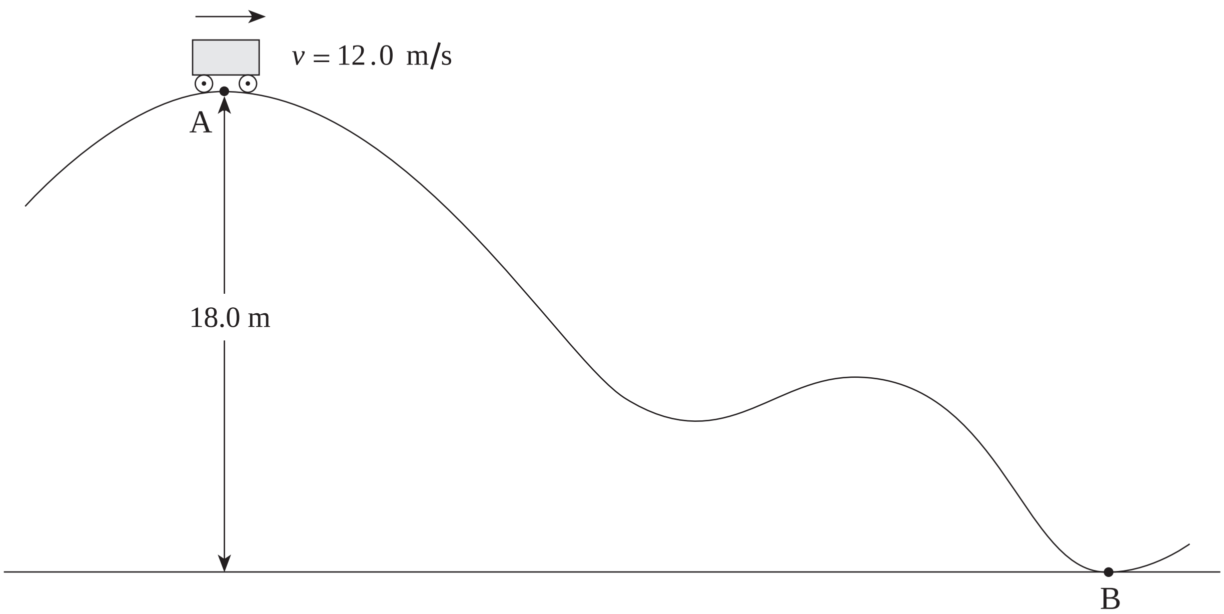
OR

$$F_{net} = m_T a$$

$$(3.0\ \text{kg})(9.8\ \text{m/s}^2) = (3\ \text{kg} + m_2)1.8\ \text{m/s}^2$$

$$m_2 = 13.3\ \text{kg}$$

2. A 250 kg roller coaster passes point A at 12.0 m/s.



What is the speed of the roller coaster at point B at the bottom of the hill if 8 500 J of energy is transformed to heat during the journey? **(7 marks)**

$$E_{T_A} = E_{T_B}$$

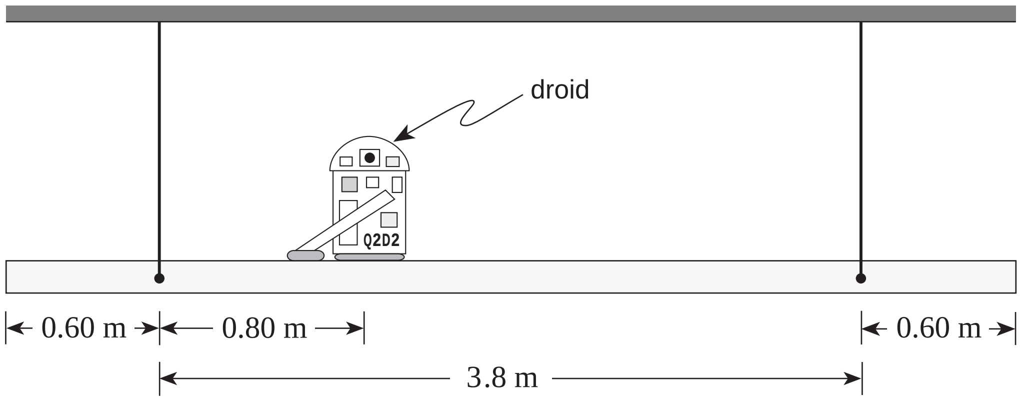
$$mgh_A + \frac{1}{2}mv_A^2 - 8\ 500\ \text{J} = \cancel{mgh} + \frac{1}{2}mv_B^2 \qquad \leftarrow \textbf{4 marks}$$

$$250\ \text{kg} \cdot 9.80\ \text{m/s}^2 \cdot 18.0\ \text{m} + \frac{1}{2} \cdot 250\ \text{kg} \cdot (12.0\ \text{m/s})^2 - 8\ 500\ \text{J} = \frac{1}{2}250\ \text{kg} \cdot v_B^2 \qquad \leftarrow \textbf{1 mark}$$

$$44\ 100\ \text{J} + 18\ 000\ \text{J} - 8\ 500\ \text{J} = 125\ \text{kg} \cdot v_B^2 \qquad \leftarrow \textbf{1 mark}$$

$$\therefore v_B = 20.7\ \text{m/s} \qquad \leftarrow \textbf{1 mark}$$

3. A 25 kg droid rests on a 5.0 m long shelf supported by two cables as shown. The mass of the shelf is 12 kg.



Find the tension in **each** cable. **(7 marks)**

Using left-hand support as fulcrum:

$$\left.\begin{aligned} \Sigma \tau_c &= \Sigma \tau_{cc} \\ \tau_D + \tau_s &= \tau_c \\ F_D d_D + F_s d_s &= F_{c_R} d_c \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$25 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot 0.80 \text{ m} + 12 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot 1.9 \text{ m} = F_{c_R} \cdot 3.8 \text{ m} \quad \leftarrow \textbf{3}\tfrac{1}{2}\textbf{ marks}$$

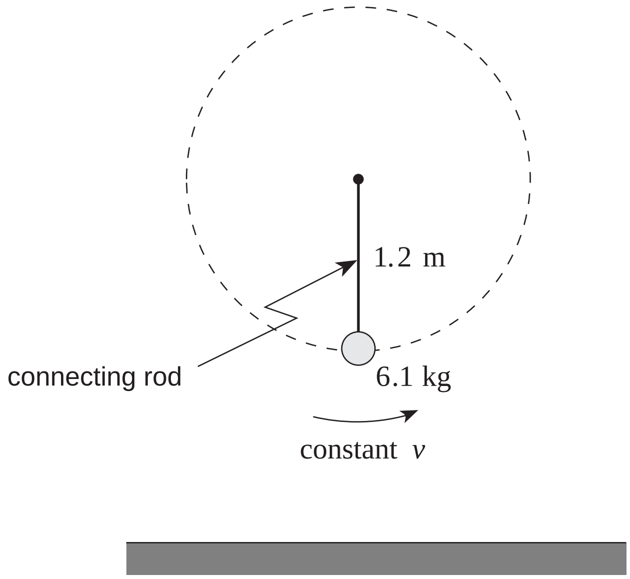
$$F_{c_R} = 110 \text{ N} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$F_{c_L} + F_{c_R} = F_g \quad \leftarrow \textbf{1 mark}$$

$$F_{c_L} + 110 \text{ N} = 363 \text{ N} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$F_{c_L} = 253 \text{ N} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

4. A $6.1\ \text{kg}$ object on the end of a massless connecting rod moves in uniform circular motion in a vertical circle with radius $1.2\ \text{m}$. The period of revolution is $0.80\ \text{s}$.



a) Draw and label a free body diagram for the object at the bottom of the circular path. **(2 marks)**

$\leftarrow$ **2 marks**

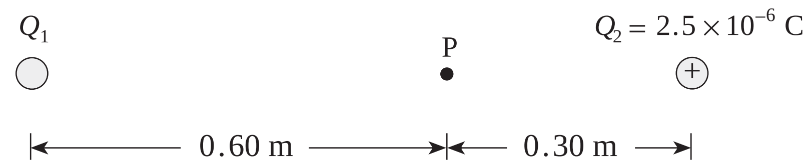
b) Calculate the tension in the connecting rod at this position. **(5 marks)**

$$\left.\begin{aligned} F_{net} &= ma \\ T - F_g &= m\left(\frac{4\pi^2}{T^2}r\right) \\ T - mg &= m\frac{4\pi^2}{T^2}r \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} T - 6.1\ \text{kg}\cdot 9.8\ \text{m/s}^2 &= \frac{6.1\ \text{kg}\cdot 4\pi^2\cdot 1.2\ \text{m}}{(0.80\ \text{s})^2} \\ T - 60\ \text{N} &= 452\ \text{N} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$T = 510\ \text{N} \qquad \leftarrow \textbf{1 mark}$$

5. Two point charges Q_1 and Q_2 are arranged as shown in the diagram below.



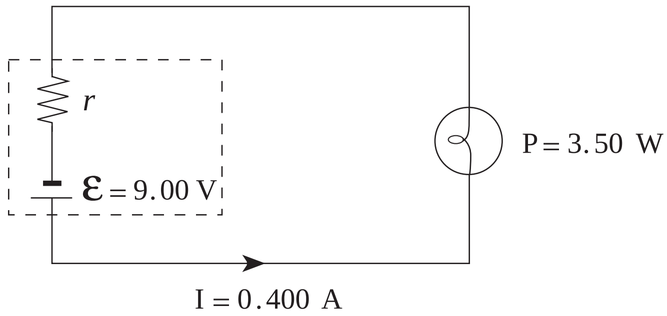
The electric potential at point P due to these charges is found to be 1.9×10^5 V. What are the magnitude and sign of charge Q_1? **(7 marks)**

$$\left.\begin{aligned} V_p &= V_1 + V_2 \\ V_2 &= \frac{kQ_2}{R_2} \\ &= \frac{9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2} \cdot 2.5 \times 10^{-6}\ \mathrm{C}}{0.30\ \mathrm{m}} \\ &= 7.5 \times 10^4\ \mathrm{V} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} \therefore V_1 &= V_p - V_2 \\ &= 1.9 \times 10^5\ \mathrm{V} - 7.5 \times 10^4\ \mathrm{V} \\ &= 1.15 \times 10^5\ \mathrm{V} \\ \therefore \frac{kQ_1}{R_1} &= 1.15 \times 10^5\ \mathrm{V} \\ \therefore Q_1 &= \frac{0.60\ \mathrm{m} \cdot 1.15 \times 10^5\ \mathrm{V}}{9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2}} \end{aligned}\right\} \leftarrow \textbf{4 marks}$$

$$= +7.7 \times 10^{-6}\ \mathrm{C} \qquad \leftarrow \textbf{1 mark}$$

6. The circuit shown in the diagram below consists of a $9.00\ \text{V}$ battery and a $3.50\ \text{W}$ light bulb.



a) If a current of $0.400\ \text{A}$ leaves the battery, what is the internal resistance, r, of the battery? **(5 marks)**

$$\left.\begin{aligned} P &= VI \\ 3.5 &= V(0.4) \\ 8.75\ \text{V} &= V \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} V_T &= \mathcal{E} - Ir \\ 8.75 &= 9 - Ir \\ 0.25 &= (0.4)r \\ 0.63\ \Omega &= r \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

b) The light bulb is now replaced by a lower resistance (brighter) light bulb. The terminal voltage will now be

- ☑ less than before.
- ☐ the same as before.
- ☐ greater than before.

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

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

The total resistance of the circuit will decrease, therefore the current through the battery will increase.

More potential will be dropped across the internal resistance, therefore the terminal voltage will decrease.

7. A single loop of wire of area $5.0 \times 10^{-3}\ \text{m}^2$ and resistance $1.8\ \Omega$ is perpendicular to a uniform magnetic field B. The field then decreases to zero in $1.2 \times 10^{-3}\ \text{s}$ inducing an average current of $8.3 \times 10^{-2}\ \text{A}$ in the loop. What was the initial value of the magnetic field B? **(7 marks)**

$$V = IR$$

$$= 8.3 \times 10^{-2}\ \text{A} \cdot 1.8\ \Omega$$

$$= 0.149\ \text{V} \qquad \leftarrow \textbf{2 marks}$$

$$\varepsilon = \frac{N\Delta\Phi}{\Delta t}$$

$$0.149\ \text{V} = \frac{-(1)(\Delta\Phi)}{1.2 \times 10^{-3}\ \text{s}}$$

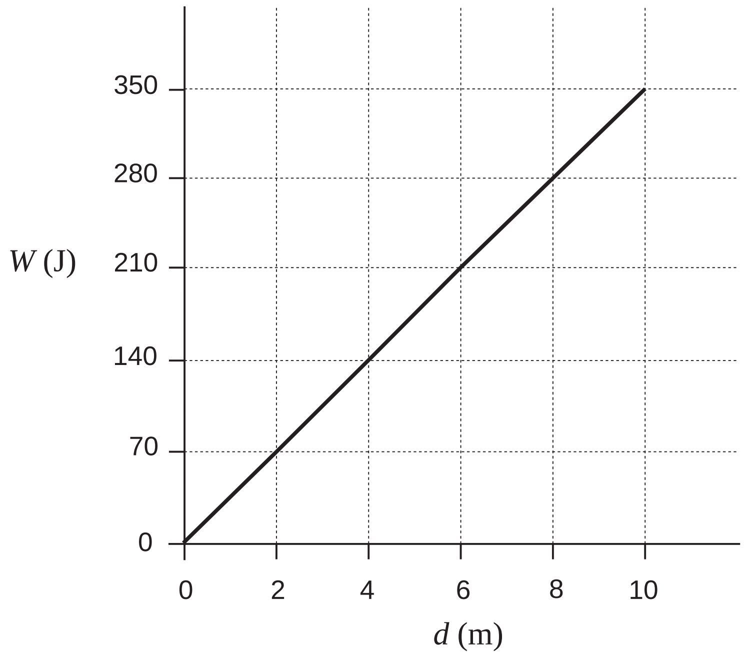
$$\Delta\Phi = -1.8 \times 10^{-4}\ \text{Wb} \qquad \leftarrow \textbf{3 marks}$$

$$\left.\begin{aligned} \Delta\Phi &= (\Delta B)A \\ \Delta B &= \frac{-1.8 \times 10^{-4}\ \text{Wb}}{5.0 \times 10^{-3}\ \text{m}^2} \\ \Delta B &= B_{final} - B_{initial} = 0 - B_{initial} \\ B_{initial} &= 3.6 \times 10^{-2}\ \text{T} \end{aligned}\right\} \qquad \leftarrow \textbf{2 marks}$$

8. A gardener does work W pushing a lawnmower a distance d across a lawn.

W (J)	70	140	210	280	350
d (m)	2.0	4.0	6.0	8.0	10.0

a) Plot a graph of W versus d on the axes below. **(2 marks)**



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

$$\boldsymbol{slope = \frac{\Delta W}{\Delta d} = 35\ \mathrm{J/m}} \quad \leftarrow \mathbf{1\tfrac{1}{2}\ marks\ \left(units,\ \tfrac{1}{2}\ mark\right)}$$

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

The slope represents the force applied to the lawnmower.

9. The front of an automobile is designed to crumple in a collision in order to reduce the injury to the occupants. Discuss briefly the physics of how this design feature improves safety for the occupants. **(4 marks)**

The crumpling of the automobile decreases the acceleration experienced by the occupants by increasing the distance to stop and/or increasing the time taken to stop.

$\Delta \boldsymbol{E}_k = \boldsymbol{F} \cdot \boldsymbol{d}$ $\qquad$ $\Delta \boldsymbol{P} = \boldsymbol{F} \cdot \Delta \boldsymbol{t}$

$\uparrow \quad \uparrow$ $\qquad\qquad$ $\uparrow$

decreased increases $\qquad$ **increases Δt so decreases F**

END OF KEY