Physics 12

August 1999 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.	B	K	1	B5, 6	16.	D	K	4	J4
2.	C	U	1	B1, 2, E7	17.	A	U	4	J9, 8
3.	B	U	1	A7	18.	D	K	5	K6
4.	D	K	1	C1, A10	19.	B	U	5	L7
5.	A	U	1	C3, 7, D6	20.	B	H	5	K8, A7
6.	B	K	2	E9, A1	21.	C	K	6	N4
7.	B	U	2	E10	22.	C	U	6	M7, 5
8.	B	U	2	F6, 7	23.	C	H	6	M11
9.	B	K	3	H4	24.	A	K	7	O3
10.	C	U	3	H2, 3	25.	C	U	7	O5
11.	C	U	3	H8, 11	26.	D	U	7	O6
12.	D	K	4	D4, I5	27.	C	U	7	P3
13.	B	U	4	I4	28.	C	U	7	P4, 6
14.	B	U	4	I4, E7	29.	D	U	7	P11, 12, 13
15.	B	U	4	C4, I4, 5	30.	D	H	7	M5, P5, 4, 6

Multiple Choice = 60 marks

PART B: Written Response

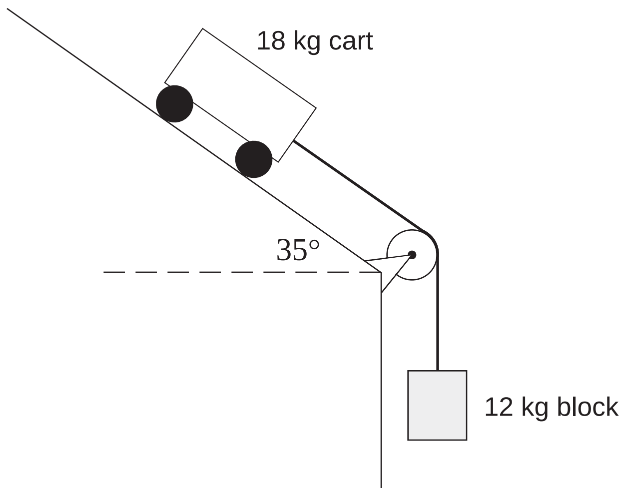
Q	B	C	S	CO	PLO
1.	1	U	7	1	C4, D4, 6
2.	2	U	7	2	F7, E7
3.	3	U	7	3	H11
4.	4	U	9	4	J9, E7
5.	5	U	7	5	L8, 6
6.	6	U	7	6	M7,5
7.	7	U	7	7	P9, M5
8	8	H	5	1	A10, P9
9.	9	H	4	2	E5, 2, 7

Written Response = 60 marks

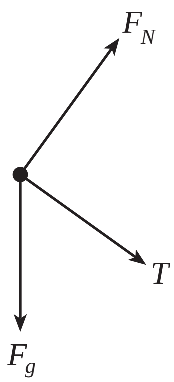
Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	**=**	**120 marks**

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

1. An 18 kg cart is connected to a 12 kg hanging block as shown. (Ignore friction.)



a) Draw and label a free body diagram for the 18 kg cart. **(2 marks)**



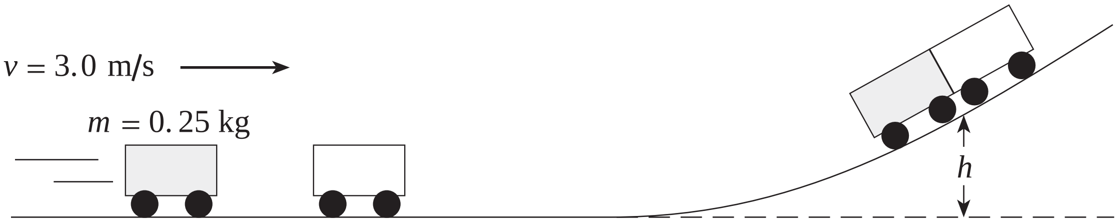
b) What is the magnitude of the acceleration of the cart? **(5 marks)**

$$\left.\begin{aligned} cart\ F_{//} &= mg\sin\theta \\ &= 18(9.8)\sin 35 \\ &= 101\ \text{N} \end{aligned}\right\} \leftarrow \mathbf{1\tfrac{1}{2}\ marks}$$

$$\left.\begin{aligned} W_{object} &= mg \\ &= 12(9.8) \\ &= 118\ \text{N} \end{aligned}\right\} \leftarrow \mathbf{1\ mark}$$

$$\left.\begin{aligned} a_{system} &= \frac{F_{net}}{m} \\ &= \frac{W_1 + F_{//}}{m_1 + m_2} \\ &= \frac{118+101}{12+18} \\ a &= 7.3\ \text{m/s}^2 \end{aligned}\right\} \leftarrow \mathbf{2\tfrac{1}{2}\ marks}$$

2. A 0.25 kg cart travelling at 3.0 m/s collides with and sticks to an identical stationary cart on a level track. (Ignore friction.)

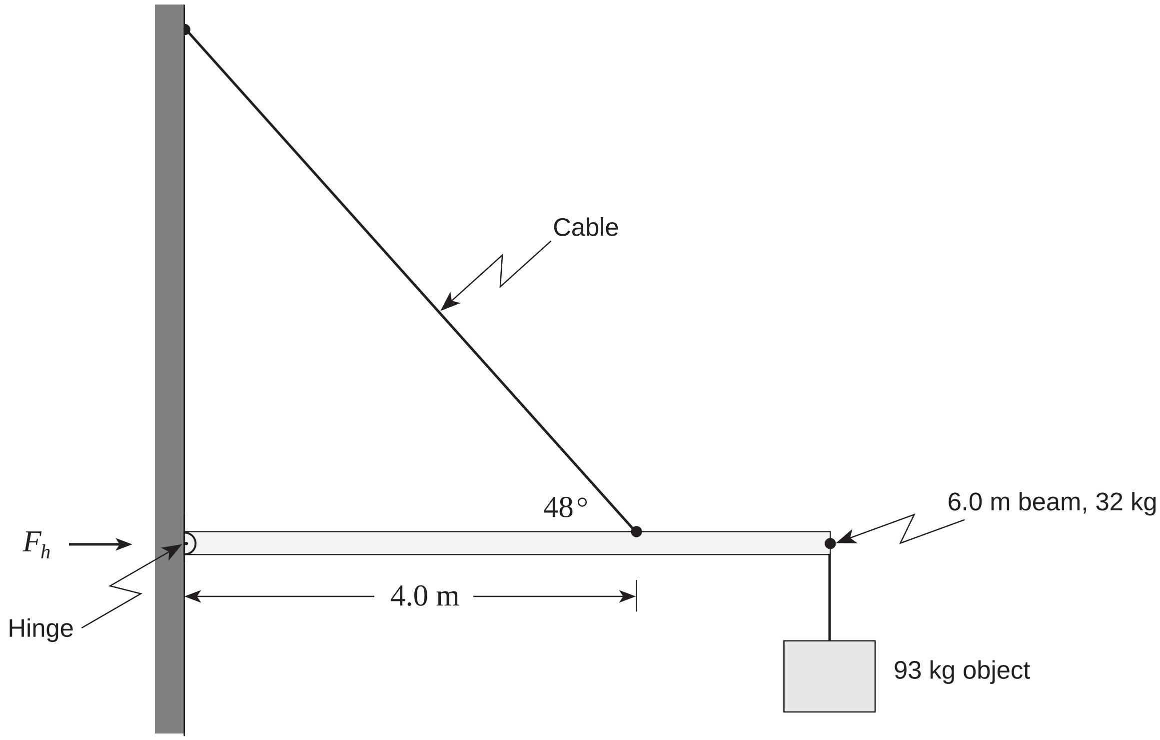


To what height h do the combined carts travel up the hill? **(7 marks)**

$$
\left.
\begin{aligned}
p_i &= p_f \\
mv_i &= (2\,m)v_f \\
v_f &= \frac{v_i}{2} \\
&= 1.5 \text{ m/s}
\end{aligned}
\right\} \leftarrow \mathbf{3\tfrac{1}{2}\ marks}
$$

$$
\left.
\begin{aligned}
\Delta E_P &= -\Delta E_k \\
(2\,m)gh_{\text{max}} &= \frac{1}{2}(2\,m)\left(v_f\right)^2 \\
h_{\text{max}} &= \frac{\left(v_f\right)^2}{2\,g} \\
&= 0.11 \text{ m}
\end{aligned}
\right\} \leftarrow \mathbf{3\tfrac{1}{2}\ marks}
$$

3. A 6.0 m uniform beam of mass 32 kg is suspended horizontally by a hinged end and a cable. A 93 kg object is connected to one end of the beam.



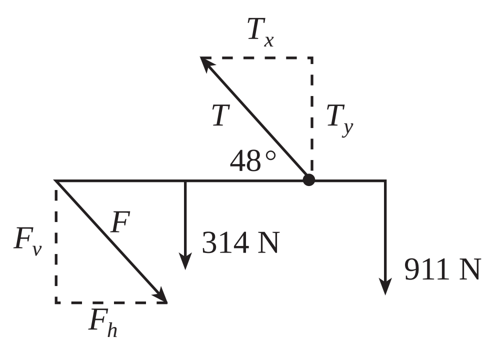
What is the magnitude of the horizontal force F_h that the hinge exerts on the beam? **(7 marks)**

$$\tau_c = \tau_{cc} \text{ about the hinge}$$
$$3.0(314) + 6.0(911) = 4.0(T)\sin 48°$$
$$942 + 5\,470 = 2.97\,T$$
$$2\,160 \text{ N} = T$$

← **5 marks**

$$T_x = F_h$$
$$T\cos 48 = F_h$$
$$2\,160\cos 48 = F_h$$
$$F_h = 1\,400 \text{ N } (1.4\times10^3 \text{ N})$$

← **2 marks**



Alternate Solution:

$$\Sigma\tau = 0 \text{ about the hinge}$$
$$(314)(3.0) - T_y(4.0) + 911(6.0) = 0$$
$$T_y = 1\,600 \text{ N}$$

← **5 marks**

$$F_h = T_x$$
$$F_h = \frac{T_y}{\tan 48}$$
$$F_h = 1\,400 \text{ N}\left(1.4\times10^3 \text{ N}\right)$$

← **2 marks**

4. A 1 500 kg satellite travels around the earth in a stable orbit with a radius of 1.3×10^{7} m.

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

$$F_{net} = ma_c$$

$$\frac{Gm_E m}{r^2} = \frac{mv^2}{r} \qquad \leftarrow \textbf{3 marks}$$

$$v = \sqrt{\frac{Gm_E}{r}}$$

$$= \sqrt{\frac{6.67\times10^{-11}\,\mathrm{N\cdot m^2/kg^2}\cdot 5.98\times10^{24}\ \mathrm{kg}}{1.3\times10^{7}\ \mathrm{m}}}$$

$$= 5.5\times10^{3}\ \mathrm{m\ s} \qquad \leftarrow \textbf{2 marks}$$

b) The satellite is then moved to a new orbit with twice the radius of the first orbit. The speed in this orbit is

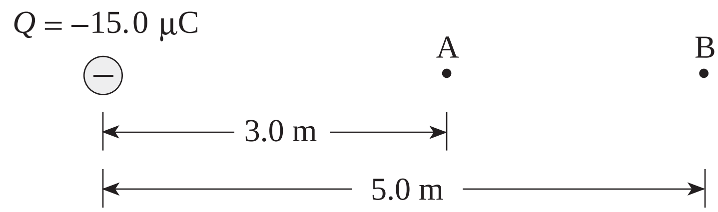
- ☐ the same as
- ☑ less than
- ☐ more than

the speed in the first orbit. (Check one response.) **(1 mark)**

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

The satellite's speed in a stable orbit is inversely proportional to the square root of orbit radius: $v \propto \frac{1}{\sqrt{r}}$. Therefore, in an orbit with twice the radius of the first, the satellite speed will be lower.

5. a) Find the electric potential at point A and at point B. (Note: $1.0\ \mu\text{C}$ is $1.0\times10^{-6}\ \text{C}$) **(3 marks)**



$$V_A = \frac{E_p}{q} = \frac{kQ}{r_A} = \frac{9.0\times10^{9}\times\left(-15.0\times10^{-6}\right)}{3.0}$$

$$= -45\,000\ \text{V}$$

$$V_B = -27\,000\ \text{V}$$

← **3 marks**

b) What is the potential difference between A and B? **(1 mark)**

$\Delta V = 18\,000\ \text{V}$ ($\pm 18\,000$ V acceptable)

c) $0.036\ \text{J}$ of work must be done to move a charge q from A to B. Find the magnitude and polarity of this charge. **(3 marks)**

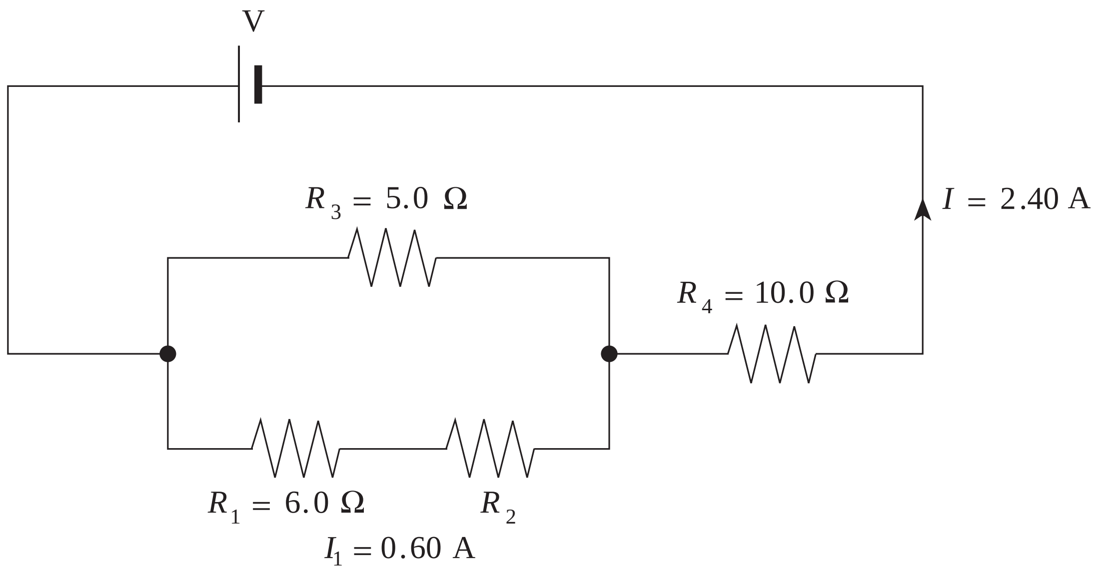
$$\Delta V = \frac{W}{q} \rightarrow q = \frac{W}{\Delta V} = \frac{0.036}{+18\,000}$$

$$= 2.0\times10^{-6}\ \text{C, positive}$$

Answer: $+2.0\times10^{-6}\ \text{C}$

← **3 marks**

6. a) Find the value of resistor R_2. **(5 marks)**



$$\left.\begin{aligned} I_3 &= I - I_1 \\ &= 2.40 - 0.60 \\ &= 1.80 \text{ A} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_3 &= I_3 R_3 \\ &= 1.80(5.0) \\ &= 9.0 \text{ V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_1 &= I_1 R_1 \\ &= 0.60(6.0) \\ &= 3.6 \text{ V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_2 &= 9.0 - 3.6 \\ &= 5.4 \text{ V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$R_2 = \frac{V_2}{I_1} = \frac{5.4}{0.60} = 9.0\ \Omega \quad \leftarrow \textbf{1 mark}$$

b) Find the potential difference of the power supply V. **(2 marks)**

$$\left.\begin{aligned} V &= V_3 + V_4 \\ &= 9.0 + I_4 R_4 \\ &= 9.0 + (2.40)(10.0) \\ &= 9.0 + 24.0 \\ &= 33.0\text{ V} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

7. An automobile starter motor, connected to a $12.0\ \text{V}$ battery, produces a back emf of $9.7\ \text{V}$ when operating at normal speed. A malfunction prevents the starter motor from turning and the current increases to $180\ \text{A}$. What current does the starter motor draw when operating normally? **(7 marks)**

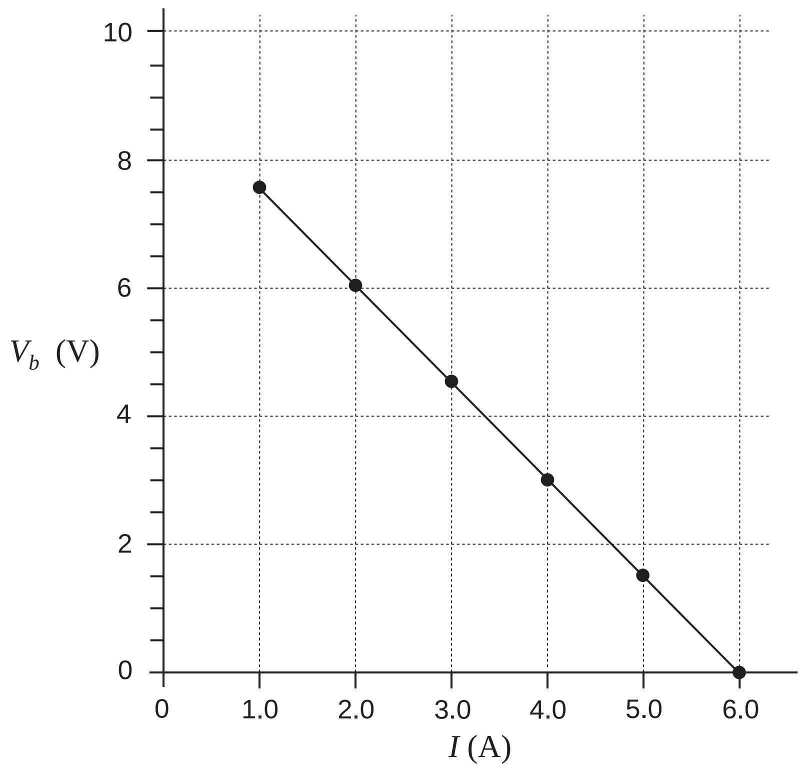
$$\left.\begin{aligned} V_b &= \varepsilon - Ir \\ I &= \frac{\varepsilon - V_b}{r} \\ r &= \frac{\varepsilon}{I} \\ r &= \frac{12.0\ \text{V}}{180\ \text{A}} \\ r &= 0.067\ \Omega \end{aligned}\right\} \leftarrow \textbf{4 marks}$$

$$\left.\begin{aligned} I &= \frac{12.0\ \text{V} - 9.7\ \text{V}}{0.067\ \Omega} \\ I &= 34\ \text{A} \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

8. An electric motor is connected to a 9.0 V power supply. The data table below shows how the back emf of the motor, V_{back}, varies with the current through the armature, I, as the mechanical load changes.

Back emf V_{back} (V)	7.5	6.0	4.5	3.0	1.5	0
Current I (A)	1.0	2.0	3.0	4.0	5.0	6.0

a) Plot this data on the graph below. **(2 marks)**



← 2 marks

b) Determine the slope of this graph. **(2 marks)**

$$slope = \frac{3.0 - 6.0 \text{ V}}{4.0 - 2.0 \text{ A}}$$

$$= -1.5 \frac{\text{V}}{\text{A}}$$

$$= -1.5\ \Omega$$

← 2 marks

c) What property of the motor does the slope of this graph represent? **(1 mark)**

internal resistance or resistance ← 1 mark

9. A cyclist must do 1 000 J of work to speed up from 0 m/s to 5.0 m/s. The same cyclist must do 3 000 J of work to speed up from 5.0 m/s to 10.0 m/s. (In both instances friction has been ignored.) Using principles of physics, explain why more work must be done to speed up from 5.0 m/s to 10.0 m/s than from 0 m/s to 5.0 m/s. (Remember, friction plays no role in this problem.) **(4 marks)**

$W = \Delta E$

$= \Delta E_k$ in this case ← **1 mark**

$E_k = \frac{1}{2}mv^2$ **(1 mark)**, so velocity changing by a factor of two will cause kinetic energy to change by a factor of four **(1 mark)** and so the work done will become ever greater as the velocity increases by uniform amounts. **(1 mark)**

OR

$W = F \cdot d$ **(1 mark)**, but if the cyclist travels faster while exerting a constant force, for each uniform increment of velocity the distance travelled will become greater **(1 mark)** and greater. Hence $W = F \cdot d$ yields greater values for W as the distance becomes larger. **(2 marks)**

END OF KEY