Physics 12

June 2000 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	CO	PLO	Q	K	C	CO	PLO
1.	A	K	1	A1	16.	D	K	4	J3, 2
2.	C	U	1	B2	17.	D	U	4	J1, 2
3.	D	U	1	B5	18.	D	K	4	K4
4.	C	K	1	C1, 3	19.	D	U	5	L8
5.	D	U	1	D4, C2	20.	C	H	5	L6
6.	A	K	2	E4, E5	21.	A	K	5	M9
7.	B	U	1	E7	22.	B	U	6	M11
8.	C	U	2	E3, 5	23.	C	H	6	M5, 6
9.	C	U	2	E10	24.	B	K	6	P2
10.	A	K	3	F5, 6, E8	25.	C	U	7	O3, 1, 2
11.	B	U	3	H3, 2	26.	C	U	7	O4
12.	D	K	3	H4	27.	B	U	7	O6
13.	C	U	4	H5, 11	28.	D	U	7	P4
14.	B	U	4	I5, D4	29.	A	U	7	P9
15.	B	U	4	I4	30.	A	H	7	O5, P1, M5, C4

Multiple Choice = 60 marks

PART B: Written Response

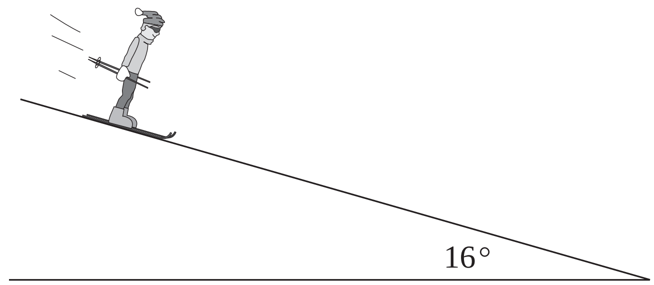
Q	B	C	S	CO	PLO
1.	1	U	7	1	C8, C3, E8
2.	2	U	7	2	G3
3.	3	U	7	3	H11
4.	4	U	9	4	J9, J8
5.	5	U	7	5	L6
6.	6	U	7	6	M5, 7
7.	7	U	7	7	P11
8	8	H	5	1	A10, B2
9.	9	H	4	7	I5

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 75 kg Olympic skier takes 20 s to reach a speed of 25 m/s from rest while descending a uniform 16° slope.



What is the coefficient of friction between the skis and the slope surface? **(7 marks)**

$$a = \frac{\Delta v}{\Delta t}$$

$$= \frac{25\ \text{m/s}}{20\ \text{s}}$$

$$= 1.25\ \text{m/s}^2$$ ← **2 marks**

$$ma = mg \sin\theta - \mu mg \cos\theta$$

$$a = g \sin\theta - \mu g \cos\theta$$

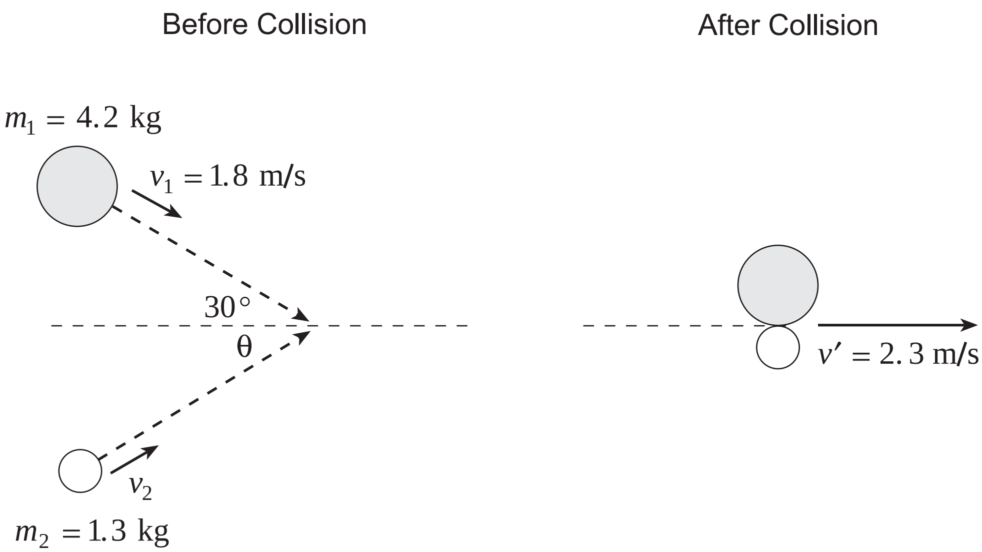
← **3 marks**

$$\mu = \frac{g \sin\theta - a}{g \cos\theta}$$ ← **1 mark**

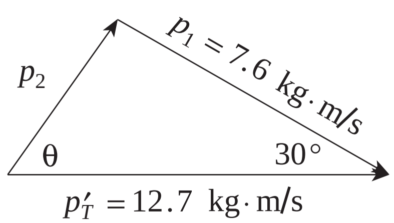
$$= \frac{9.8\ \text{m/s}^2 \cdot \sin 16° - 1.25\ \text{m/s}^2}{9.8\ \text{m/s}^2 \cdot \cos 16°}$$

$$= 0.15$$ ← **1 mark**

2. Two steel pucks are moving as shown in the diagram. They collide inelastically.



Determine the speed and direction (angle θ) of the 1.3 kg puck before the collision. **(7 marks)**



$$\left.\begin{aligned} p_1 &= m_1 v_1 \\ &= 4.2 \times 1.8 \\ &= 7.6 \text{ kg}\cdot\text{m/s} \\ p'_T &= m_T v'_1 \\ &= 5.5 \times 2.3 \\ &= 12.7 \text{ kg}\cdot\text{m/s} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

Method 1:

Cosine Law:

$$p_2{}^2 = (p'_T)^2 + p_1{}^2 - 2 p'_T p_1 \cos 30°$$

$$= 12.7^2 + 7.6^2 - 2 \times 12.7 \times 7.6 \times \cos 30°$$

$$p_2{}^2 = 51.9$$

$$p_2 = \sqrt{51.9} = 7.20 \text{ kg m/s} \qquad \leftarrow \textbf{3 marks}$$

$$v_2 = \frac{p_2}{m_2} = \frac{7.20 \text{ kg m/s}}{1.3 \text{ kg}} = 5.5 \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

Sine Law:

$$\left.\begin{aligned}
\frac{\sin\theta}{7.6} &= \frac{\sin 30^\circ}{7.2} \\
\sin\theta &= \frac{7.6 \times \sin 30^\circ}{7.2} \\
\sin\theta &= 0.528 \\
\theta &= 32^\circ
\end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$v_2 = 5.5 \text{ m/s at } 32^\circ$$

<u>Method 2:</u> (one variation)

$$m_1 v_1 \cos 30^\circ + m_2 v_2 \cos\theta = m_T v' \qquad \leftarrow \textbf{1 mark}$$

$$4.2(1.8)\cos 30^\circ + 1.3(v_2)\cos\theta = (4.2 + 1.3)(2.3) \qquad \leftarrow \textbf{1 mark}$$

$$v_2 = \frac{4.69}{\cos\theta} \qquad \leftarrow \textbf{1 mark}$$

$$m_1 v_1 \sin 30^\circ + m_2 v_2 \sin\theta = 0 \qquad \leftarrow \textbf{1 mark}$$

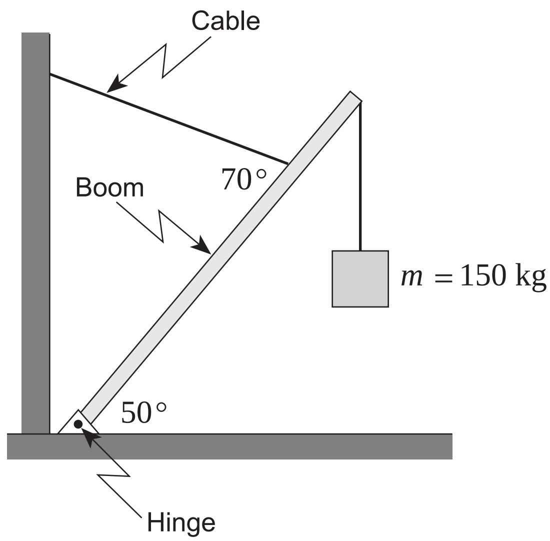
$$4.2(1.8)\sin 30^\circ + 1.3(v_2)\sin\theta = 0 \qquad \leftarrow \textbf{1 mark}$$

$$v_2 = \frac{2.91}{\sin\theta}$$

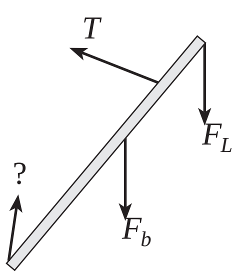
$$\left.\begin{aligned}
\frac{4.69}{\cos\theta} &= \frac{2.91}{\sin\theta} \\
\frac{\sin\theta}{\cos\theta} &= \frac{2.91}{4.69} \\
\tan\theta &= 0.618 \\
\theta &= 32^\circ
\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned}
v_2 &= \frac{4.69}{\cos 31.8} \\
v_2 &= 5.5 \text{ m/s}
\end{aligned}\right\} \leftarrow \textbf{1 mark}$$

3. A uniform 6.0 m-long boom has a mass of 55 kg. It is kept in position by a restraining cable attached three-quarters of the way along the boom.



What is the tension in this cable when the boom supports a 150 kg mass as shown? **(7 marks)**



About the hinge:

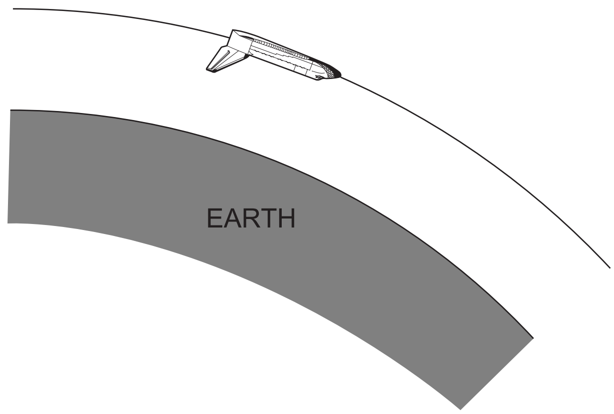
$$\Sigma\tau = 0 \qquad \leftarrow \textbf{1 mark}$$

$$\tau_{cable} - \tau_{mass} - \tau_{boom} = 0 \qquad \leftarrow \textbf{1 mark}$$

$$(T\cos 20)\left(\frac{3}{4}\cdot 6\right) - \left(150(9.8)\cos 50\right)(6) - \left(55(9.8)\cos 50\right)\left(\frac{1}{2}\cdot 6\right) = 0 \qquad \leftarrow \textbf{4 marks}$$

$$T = 1\,600\text{ N} \qquad \leftarrow \textbf{1 mark}$$

4. A space shuttle is placed in a circular orbit at an altitude of 3.00×10^5 m **above** Earth's surface.



a) What is the shuttle's orbital speed? **(5 marks)**

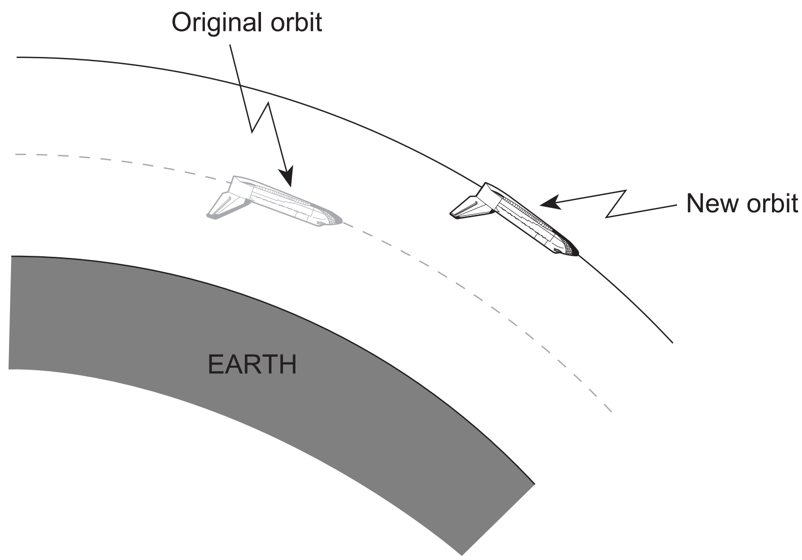
$$F_c = F_g \qquad \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} m\frac{v^2}{R} &= \frac{GMm}{R^2} \\ v^2 &= \frac{GM}{R} \\ v &= \sqrt{\frac{GM}{R}} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$= \sqrt{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.68 \times 10^6}} \qquad \leftarrow \textbf{1 mark}$$

$$v = 7.73 \times 10^3 \text{ m s} \qquad \leftarrow \textbf{1 mark}$$

b) The space shuttle is then moved to a higher orbit in order to capture a satellite.



The shuttle's speed in this new higher orbit will have to be

- ☐ greater than in the lower orbit.
- ☑ less than in the lower orbit.
- ☐ the same as in the lower orbit.

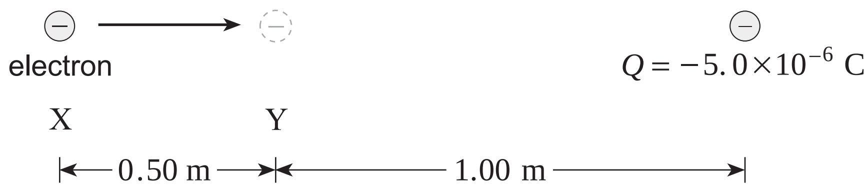
(Check one response.) **(1 mark)**

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

As the space shuttle moves further away from the earth's centre the force of gravity acting on the shuttle decreases. Since the centripetal force is provided by the force of gravity, it must decrease as well. ← 2 marks

The smaller centripetal force generates a smaller centripetal acceleration ← 1 mark which in turn requires a smaller orbital velocity.

5. a) How much work is done in moving an electron from point X to point Y? **(5 marks)**



$W = \Delta Ep$

$= \dfrac{kQq}{r_2} - \dfrac{kQq}{r_1}$ ← **2 marks**

$= \dfrac{9.0\times10^{9}\times -5.0\times10^{-6}\times -1.60\times10^{-19}}{1.00} - \dfrac{9.0\times10^{9}\times -5.0\times10^{-6}\times -1.60\times10^{-19}}{1.50}$ ← **2 marks**

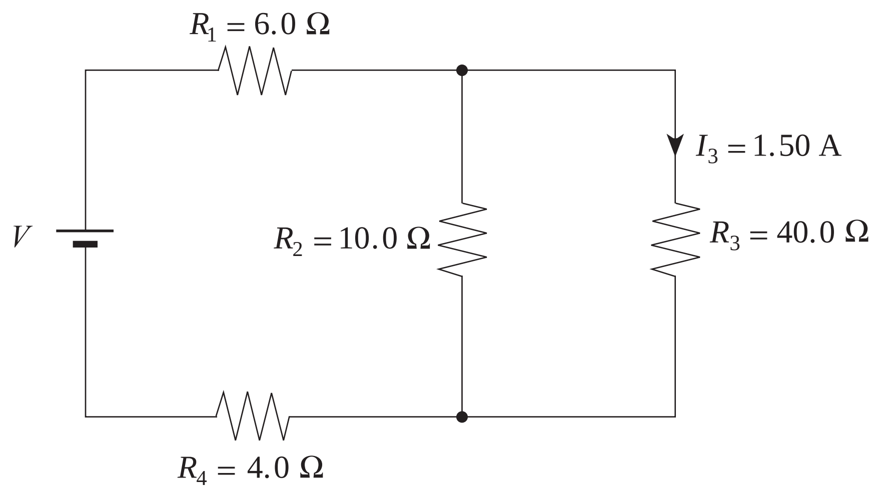
$= 2.4\times10^{-15}$ J ← **1 mark**

b) What is the potential difference between point X and point Y? **(2 marks)**

$\Delta V = \dfrac{W}{q} = 1.5\times10^{4}$ V ← **2 marks**

Note: Both positive and negative answers will be accepted for b).

6. A current of $1.50\ \text{A}$ flows through the $40.0\ \Omega$ resistor.



What is the potential difference of the power supply? **(7 marks)**

$$\left.\begin{aligned} V_3 &= I_3 R \\ &= 1.50(40.0) \\ V_3 &= 60.0\ \text{V} \\ V_2 &= V_3 = 60.0\ \text{V} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$I_2 = \frac{V_2}{R_2} = \frac{60.0}{10.0} = 6.00\ \text{A} \qquad \leftarrow \textbf{1 mark}$$

$$I_t = I_3 + I_2 = 1.50 + 6.00 = 7.50\ \text{A} \qquad \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_1 &= I_1 R_1 \\ V_1 &= 7.50(6.0) \\ V_1 &= 45\ \text{V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_4 &= I_4 R_4 \\ &= 7.50(4.0) \\ V_4 &= 30\ \text{V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_t &= V_b = V_1 + V_{||} + V_4 \\ &= 45 + 60 + 30 \\ V_b &= 135\ \text{V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

Alternate Solution:

$$\left.\begin{aligned} V_3 &= I_3 R \\ &= 1.50(40.0) \\ V_3 &= 60.0\ \text{V} \\ V_2 &= V_3 = 60.0\ \text{V} \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$I_2 = \frac{V_2}{R_2} = \frac{60.0}{10.0} = 6.00\ \text{A} \qquad \leftarrow \textbf{1 mark}$$

$$I_t = I_3 + I_2 = 1.50 + 6.00 = 7.50\ \text{A} \qquad \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} R_p &= \frac{1}{\frac{1}{R_3} + \frac{1}{R_2}} = \frac{1}{\frac{1}{40.0} + \frac{1}{10.0}} \\ &= 8.00\ \Omega \\ R_T &= 6.0\ \Omega + 8.0\ \Omega + 4.0\ \Omega \\ &= 18.0\ \Omega \end{aligned}\right\} \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned} V_0 &= (I_0)(R_T) \\ &= (7.50)(18.0) = 135\ \text{V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

7. A transformer has 840 primary and 56 secondary windings. The primary coil is connected to a 110 V ac power supply which delivers a $0.30\ \text{A}$ current to the transformer.

a) Find the secondary voltage. **(4 marks)**

$$\left.\begin{aligned} \frac{V_s}{V_p} &= \frac{N_s}{N_p} \\ \frac{V_s}{110} &= \frac{56}{840} \\ V_s &= 7.3\ \text{V} \end{aligned}\right\} \leftarrow \textbf{4 marks}$$

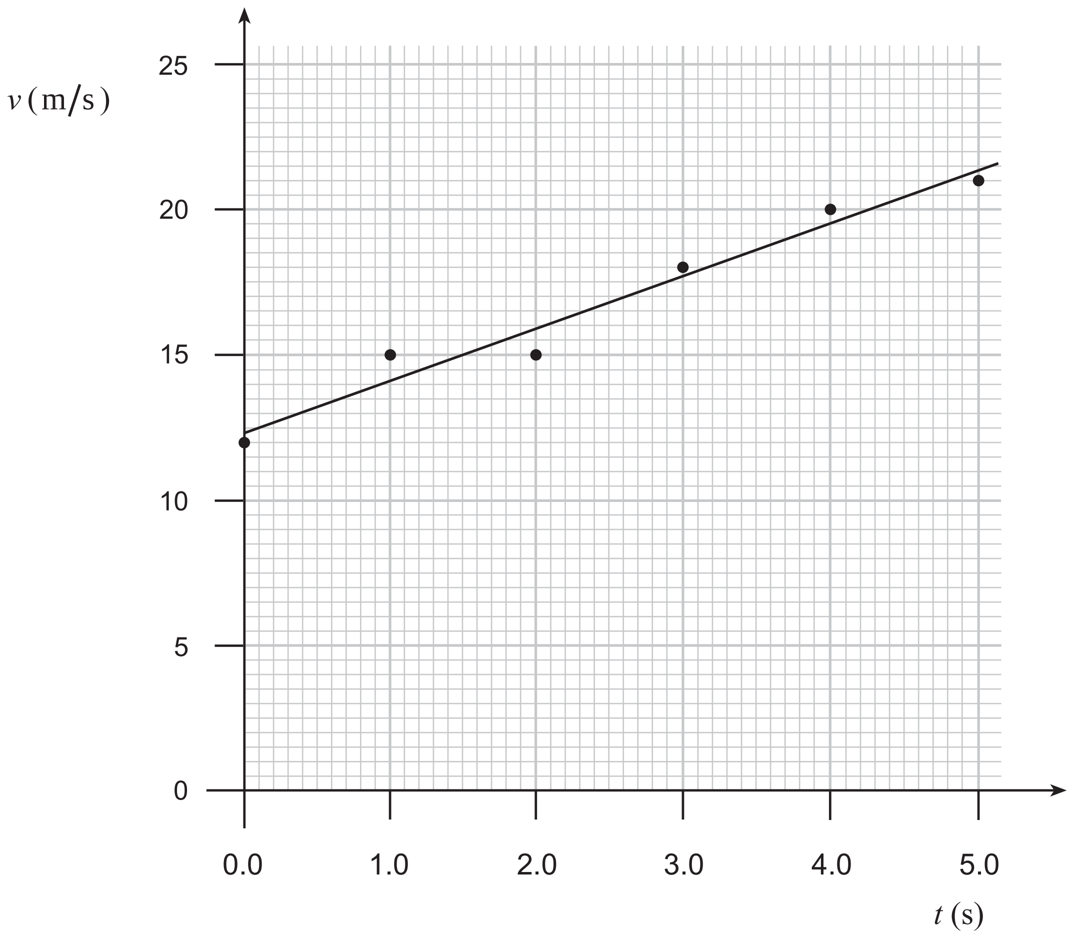
b) Find the secondary current. **(3 marks)**

$$\left.\begin{aligned} \frac{I_p}{I_s} &= \frac{N_s}{N_p} \\ \frac{0.30}{I_s} &= \frac{56}{840} \\ I_s &= 4.5\ \text{A} \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

8. The data table shows the velocity of a car during a 5.0 s interval.

t (s)	0.0	1.0	2.0	3.0	4.0	5.0
v (m/s)	12	15	15	18	20	21

a) Plot the data and draw a best-fit straight line. **(2 marks)**



b) Calculate the area bounded by the graph and the time axis between $t = 0.0$ s and $t = 5.0$ s. **(2 marks)**

$Area = \frac{1}{2}(a+b)c$

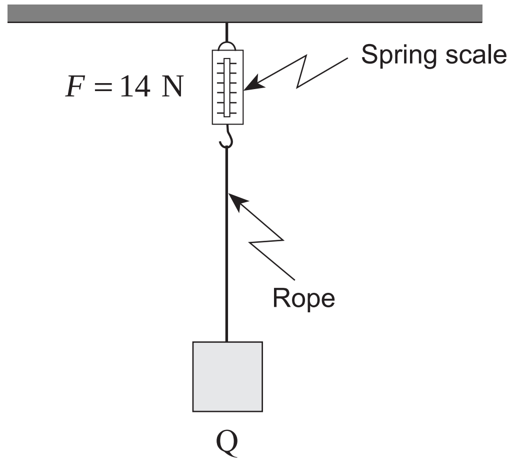
$\cong 85$ m $\leftarrow$ **2 marks**

c) What does this area represent? **(1 mark)**

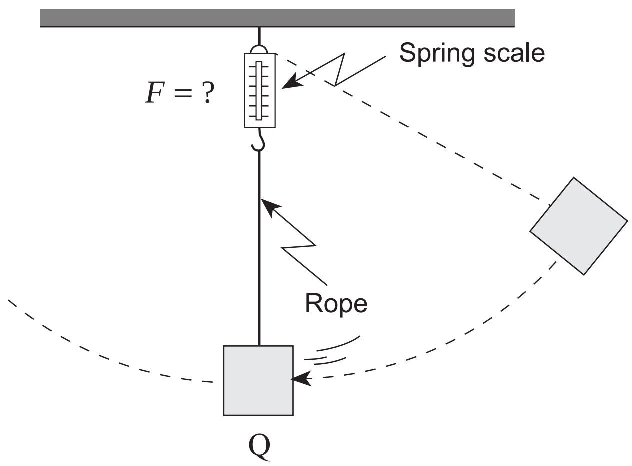
The area represents the distance (displacement) travelled by the car in the time $t = 0$ to $t = 5$ s.

"Metres" only $\leftarrow \frac{1}{2}$ mark

9. A mass is suspended by a string attached to a spring scale that initially reads 14 N as shown in Diagram 1.



The mass is pulled to the side and then released as shown in Diagram 2.



As the mass passes point Q, how will the reading on the spring scale compare to the previous value of 14 N? Using principles of physics, explain your answer. **(4 marks)**

The reading will be greater than 14 N. $\left(\text{by } \dfrac{mv^2}{r}\right)$ $\leftarrow$ **1 mark**

Initially, the net force is zero, so the spring scale reads the weight of the mass. When moving, there is a net (centripetal) force provided by the spring scale (tension in the rope) which exceeds the weight (force of gravity) of the mass so that the mass goes in a vertical circle. $\leftarrow$ **3 marks**

END OF KEY