Physics 12

January 2000 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	B1	16.	D	K	4	J3, A10
2.	D	U	1	A6	17.	B	U	4	J9
3.	C	U	1	B8	18.	C	H	4	J10, 2
4.	C	K	1	D5	19.	A	K	5	K6
5.	C	U	2	E2	20.	C	U	5	L6, 3
6.	D	K	2	F1	21.	C	U	5	K5, L8
7.	B	U	2	F4	22.	D	U	6	M6
8.	B	U	2	F7, 6	23.	B	U	6	M5, N2
9.	C	U	2	G3	24.	C	K	7	O2
10.	A	K	3	H4	25.	D	U	7	O3
11.	A	U	3	H2	26.	B	U	7	O4
12.	C	H	3	H5, 11	27.	C	U	7	O8
13.	C	K	4	I1	28.	A	U	7	P1
14.	C	U	4	I4	29.	C	U	7	P9
15.	A	U	4	I4, 5	30.	B	H	7	P6

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	D5, C8, D3
2.	2	U	7	2	E7, 10, 2
3.	3	U	7	3	H3
4.	4	U	7	4	J2, B2
5.	5	U	7	5	L6, 5
6.	6	U	9	6	M11, N2
7.	7	U	7	7	P5, P3
8	8	H	5	1	A10, E7
9.	9	H	4	1	C8, D4

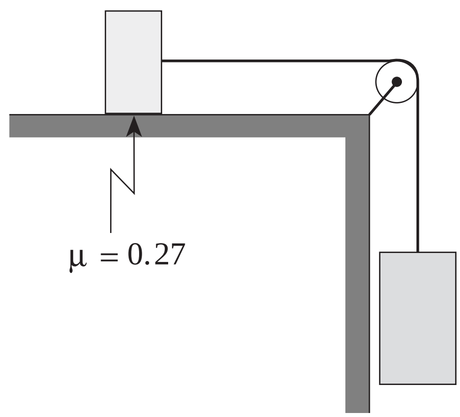
Written Response = 60 marks

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

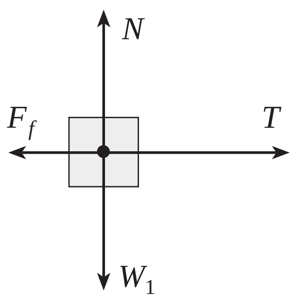
LEGEND:

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

1. Two masses are connected by a light string over a frictionless massless pulley. There is a coefficient of friction of 0.27 between mass m_1 and the horizontal surface.



a) Draw and label a free body diagram showing the forces acting on mass m_1. **(2 marks)**



← **2 marks**

b) What is the acceleration of mass m_2? **(5 marks)**

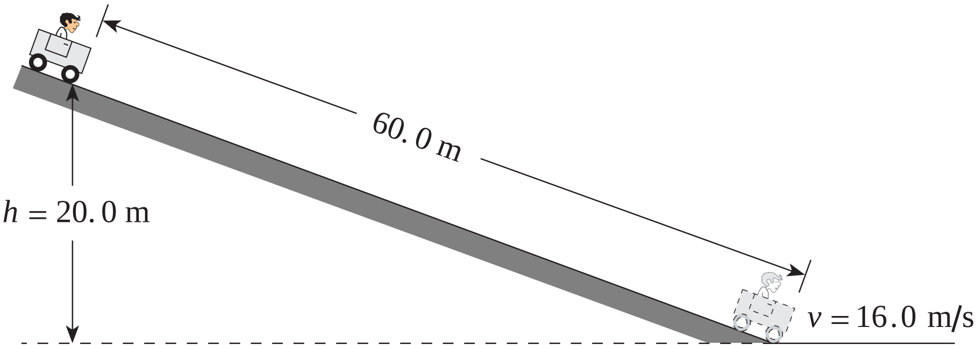
$$a = \frac{F_{net}}{m}$$ ← **½ mark**

$$= \frac{m_2 g - \mu m_1 g}{(m_1 + m_2)}$$ ← **3½ marks**

$$= \frac{4.0\ \text{kg}(9.8\ \text{N/kg}) - (0.27)(2.0\ \text{kg})(9.8\ \text{N/kg})}{(2.0\ \text{kg} + 4.0\ \text{kg})}$$ ← **½ mark**

$$= 5.7\ \text{m/s}^2$$ ← **½ mark**

2. A 170 kg cart and rider start from rest on a $20.0\ \text{m}$ high incline.



a) How much energy is transformed to heat? **(5 marks)**

$$\Delta E = 0$$

$$Ep = E_k + Heat \quad \leftarrow \textbf{2 marks}$$

$$mgh = \tfrac{1}{2}mv^2 + Heat \quad \leftarrow \textbf{1 mark}$$

$$170(9.8)20.0 = \tfrac{1}{2}(170)16.0^2 + E_h \quad \leftarrow \textbf{1 mark}$$

$$33\,320 = 21\,760 + E_h$$

$$1.16 \times 10^4\ \text{J} = E_h \quad \leftarrow \textbf{1 mark}$$

b) What is the average force of friction acting on the cart? **(2 marks)**

$E_h =$ work done by friction

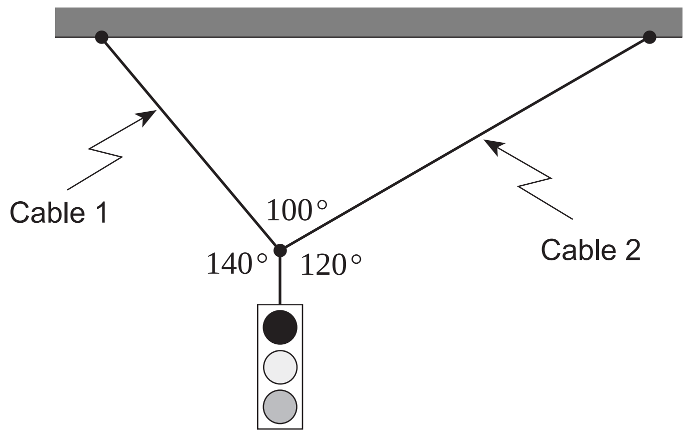
$$11560 = F_f \cdot d$$

$$\therefore F_f = \frac{11\,560}{60.0}$$

$$F_f = 193\ \text{N}$$

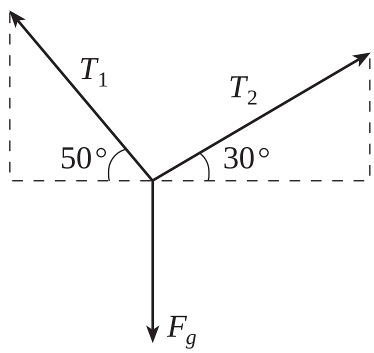
$$F_f = 190\ \text{N} \quad \leftarrow \textbf{2 marks}$$

3. A 35 kg traffic light is suspended from two cables as shown in the diagram.



What is the tension in each of these cables? **(7 marks)**

Component Method:



← **2 marks**

$$\Sigma F_x = 0$$

$$T_1 \cos 50° = T_2 \cos 30°$$

$$T_1 = T_2 \frac{\cos 30°}{\cos 50°}$$

$$\Sigma F_y = 0$$

$$T_1 \sin 50° + T_2 \sin 30° = 35(9.8)$$

$$\left(T_2 \frac{\cos 30°}{\cos 50°}\right)\sin 50° + T_2 \sin 30° = 343$$

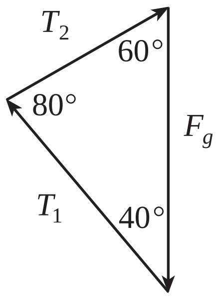
$$T_2 = \frac{343}{1.03 + 0.5}$$

$$T_2 = 224 \text{ N}$$

$$\mathrm{T}_1 = 224 \frac{\cos 30°}{\cos 50°}$$

$$= 302 \text{ N}$$

Vector Method:



← **3 marks**

$$\frac{\sin 80°}{F_g} = \frac{\sin 60°}{T_1}$$

$$T_1 = \frac{\sin 60°}{\sin 80°} \cdot F_g$$

$$= 0.879 \cdot 35\ \text{kg} \cdot 9.8\ \text{m/s}^2$$

$$= 3.0 \times 10^2\ \text{N}$$

} **1 ½ marks**

$$F = mg = (35\ \text{kg})(9.8\ \text{N/kg}) = 343\ \text{N}$$ ← **1 mark**

$$\frac{\sin 80°}{F_g} = \frac{\sin 40°}{T_2}$$

$$T_2 = 2.2 \times 10^2\ \text{N}$$

} **1 ½ marks**

4. A $5.0\ \text{kg}$ rock dropped near the surface of Mars reaches a speed of $15\ \text{m/s}$ in $4.0\ \text{s}$.

a) What is the acceleration due to gravity near the surface of Mars? **(2 marks)**

$$a = \frac{\Delta v}{\Delta t} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{15}{4.0} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$= 3.8\ \text{m/s}^2 \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

OR

$$d = v_{ave} \times t$$

$$= 7.5 \times 4 = 30\ \text{m} \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

$$v^2 = v_0{}^2 + 2ad \qquad \leftarrow \textbf{1 mark}$$

$$15^2 = 2(a)(30)$$

$$a = 3.8\ \text{m/s}^2 \qquad \leftarrow \tfrac{1}{2}\ \textbf{mark}$$

b) Mars has an average radius of $3.38 \times 10^6\ \text{m}$. What is the mass of Mars? **(5 marks)**

$$F_g = \frac{GMm}{R^2} \qquad \leftarrow \textbf{1 mark}$$

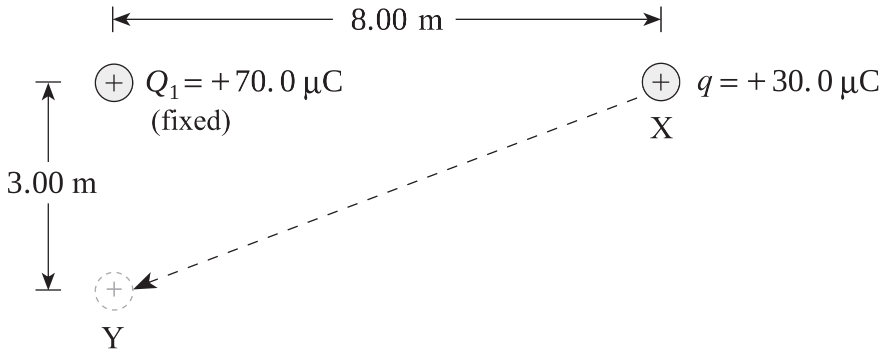
$$\not{m}g = \frac{GM\not{m}}{R^2} \qquad \leftarrow \textbf{1 mark}$$

$$\therefore M = \frac{gR^2}{G} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{3.8 \times \left(3.38 \times 10^6\right)^2}{6.67 \times 10^{-11}} \qquad \leftarrow \textbf{1 mark}$$

$$= 6.5 \times 10^{23}\ \text{kg} \qquad \leftarrow \textbf{1 mark}$$

5. A charge q of $30.0\ \mu C$ is moved from point X to point Y.



How much work is done on the $30.0\ \mu C$ charge? $\left(1\ \mu C = 1\times10^{-6}\ C\right)$ **(7 marks)**

$W = \Delta E$ ← **1 mark**

$= E_{p_y} - E_{p_x}$ ← **2 marks**

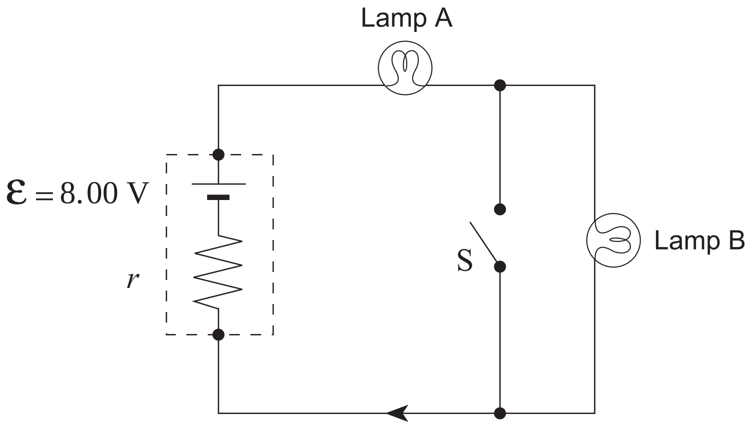
$= \dfrac{kQq}{r_y} - \dfrac{kQq}{r_x}$ ← **1 mark**

$= \dfrac{9.00\times10^{9}\cdot 70.0\times10^{-6}\cdot 30.0\times10^{-6}}{3.00} - \dfrac{9.00\times10^{9}\cdot 70.0\times10^{-6}\cdot 30.0\times10^{-6}}{8.00}$

$= (6.3 - 2.4)\ J$ ← **2 marks**

$= 3.9\ J$ ← **1 mark**

6. The circuit shown consists of an 8.00 V battery and two light bulbs. Each light bulb dissipates 5.0 W. Assume that the light bulbs have a constant resistance. Switch S is open.



a) If a current of 1.50 A flows in the circuit, what is the internal resistance r of the battery?

(4 marks)

Resistance Solution:

$$P = I^2R$$

$$\therefore R_{bulb} = \frac{P}{I^2}$$

$$= \frac{5.0}{(1.50)^2}$$

$$= 2.22\ \Omega \leftarrow \textbf{1 mark}$$

$$R_T = \frac{\varepsilon}{I}$$

$$= \frac{8.00}{1.50}$$

$$= 5.33\ \Omega \leftarrow \textbf{1 mark}$$

$$\therefore r = R_T - 2 \cdot (R_{bulb})$$

$$= 5.33 - 2(2.22) \leftarrow \textbf{1 mark}$$

$$= 0.89\ \Omega \leftarrow \textbf{1 mark}$$

Voltage Solution:

$$\left.\begin{aligned} P &= IV \\ 5 &= 1.5\ V \\ V_{bulb} &= 3.3\ \text{V} \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_{terminal} &= 3.3 \times 2 \\ V_{terminal} &= 6.7 \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$\left.\begin{aligned} V_{terminal} &= \varepsilon - Ir \\ 6.7 &= 8 - 1.5r \end{aligned}\right\} \leftarrow \textbf{1 mark}$$

$$r = 0.89\ \Omega \leftarrow \textbf{1 mark}$$

Power Solution:

$$P_T = IV$$

$$= 1.5(8)$$

$$= 12\ \text{W} \quad \leftarrow \textbf{1 mark}$$

$$P_{bulbs} = 2(5) = 10 \leftarrow \textbf{1 mark}$$

$$P_r = 12 - 10 \quad \leftarrow \textbf{1 mark}$$

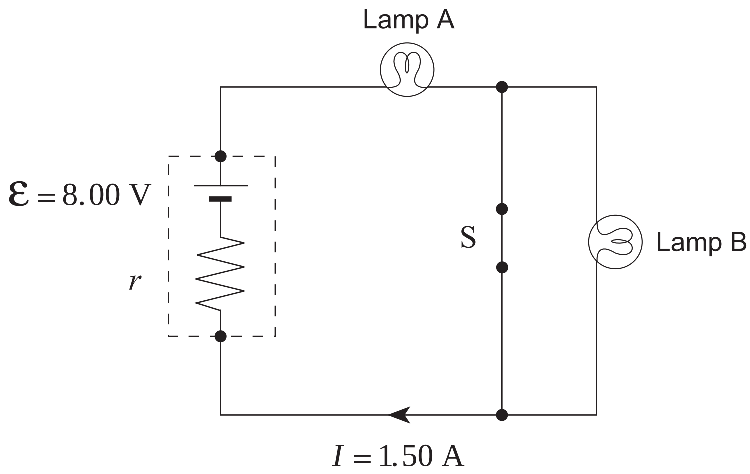
$$P_r = 2\ \text{W}$$

$$P = I^2R$$

$$r = \frac{2}{1.5^2}$$

$$= 0.89\ \Omega \quad \leftarrow \textbf{1 mark}$$

b) The switch S is now closed. **DELETED**



Lamp A will now be **(1 mark)**

i) ☑ brighter.
☐ the same brightness as before.
☐ dimmer.

(Check one response.)

The battery's terminal voltage will now be **(1 mark)**

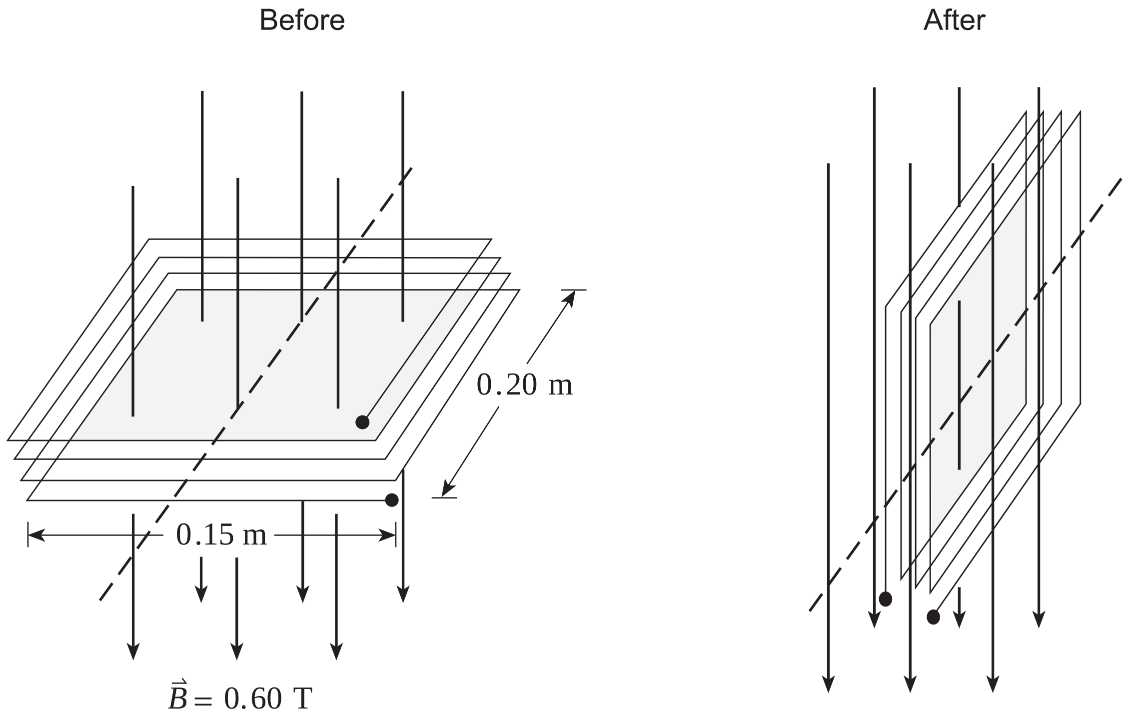
ii) ☐ greater than before.
☐ the same as before.
☑ less than before.

(Check one response.)

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

Total circuit resistance decreases when the switch is closed. Therefore, the circuit current increases. ← 1 mark
Since $P = I^2 R$, the power dissipated by Lamp A increases and it will therefore be brighter. ← 1 mark
Since the circuit current has increased, the voltage drop across the internal resistance increases and the terminal voltage drops. ← 1 mark

7. The diagram shows a coil with 25 windings and dimensions 0.15 m by 0.20 m. Its plane is perpendicular to a magnetic field of magnitude 0.60 T.



If the coil rotates 90° in 4.17×10^{-2} s so that its plane is now parallel to the magnetic field, what average emf is induced during this time? **(7 marks)**

$\mathcal{E} = -N \dfrac{\Delta\Phi}{\Delta t}$ (ignore direction term) ← **2 marks**

$$\mathcal{E} = \frac{N \times \Delta\Phi}{\Delta t}$$

$$= \frac{N \times (\Phi' - \Phi)}{\Delta t}$$

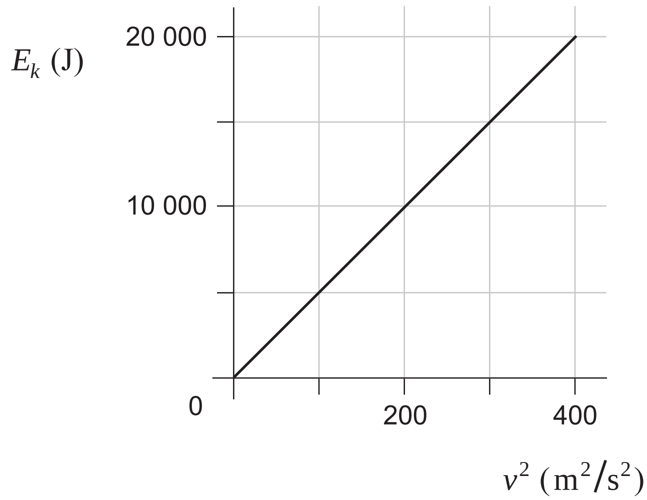
$$= \frac{N \times (0 - \mathrm{BA})}{\Delta t}$$

$$= \frac{25 \times 0.60 \times 0.15 \times 0.20}{4.17 \times 10^{-2}}$$ ← **4 marks**

$= 10.8$ V

$= 11$ V ← **1 mark**

8. A student plots the graph below, showing the kinetic energy E_k of a motorbike versus the square of its velocity v^2.



a) What is the slope of this graph? **(2 marks)**

$$slope = \frac{\Delta E_k}{\Delta v^2}$$
$$= \frac{20\ 000\ \text{J}}{400\ \text{m}^2/\text{s}^2}$$
$$= 50\ \text{J}/\text{m}^2/\text{s}^2 \qquad \leftarrow \textbf{2 marks}$$

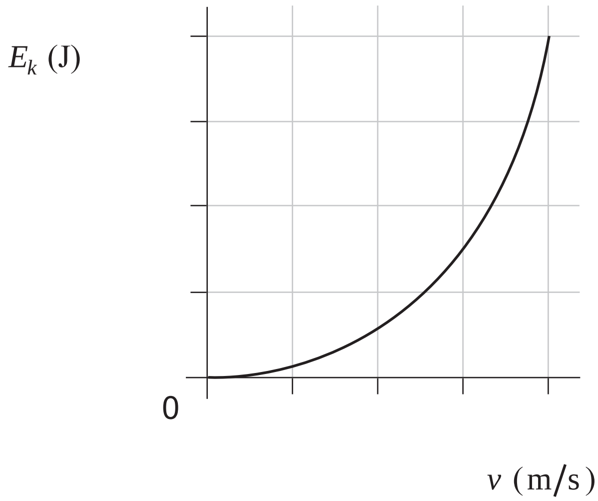
or 50 kg

b) What does the slope represent? **(2 marks)**

From the graph: $E_k = kv^2, \quad \therefore \left(E_k = 50\ v^2\right)$ $\leftarrow$ **1 mark**

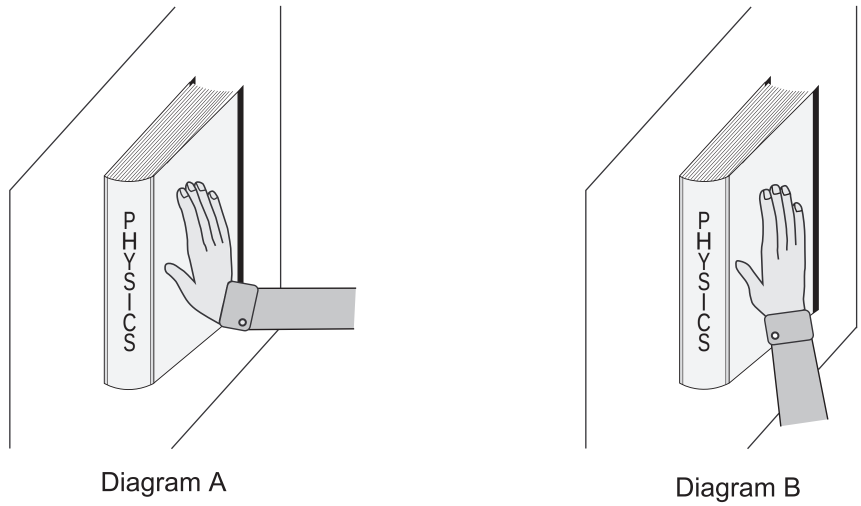
But $E_k = \frac{1}{2}mv^2$**, therefore the slope represents one half the mass of the motorbike.** $\leftarrow$ **1 mark**

c) Using the axes below, sketch the graph of kinetic energy E_k versus velocity v for this motorbike. There is no need to plot any data points. **(1 mark)**



← **1 mark**

9. A classmate insists a book cannot be held against a wall by pushing horizontally as shown in Diagram A. He insists that there must be a vertical force component, provided by pushing against the book from below, as shown in Diagram B.



Using principles of physics, show that the situation in Diagram A is reasonable. **(4 marks)**

A normal force opposite to the applied force exists. i.e., Newton's third law. ← 1 mark
Some friction force $\left(F_f\right)$ exists. ← 1 mark
The friction force depends on the normal force. ← 1 mark
With a sufficiently large enough applied force the friction force can oppose the force of gravity. ← 1 mark

END OF KEY