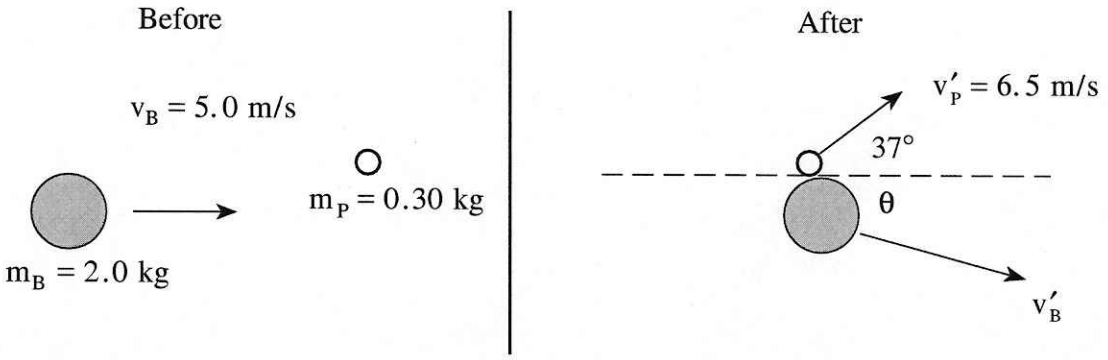
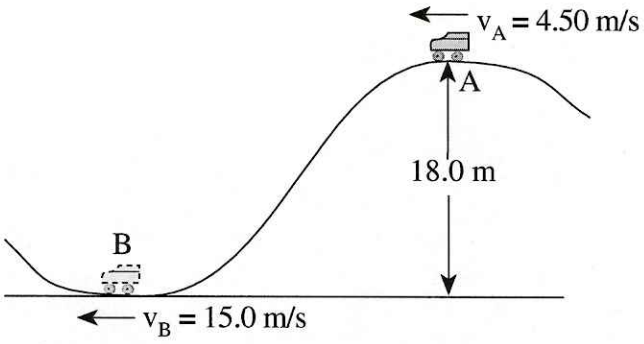
8. A 2.0 kg bowling ball travelling 5.0 m/s collides with a stationary 0.30 kg bowling pin. After the collision, the pin moves at a speed of 6.5 m/s in the direction shown in the diagram. What is the velocity (magnitude and direction) of the bowling ball after the collision? **(7 marks)**



9. A 5.20 kg block sliding at 9.40 m/s across a horizontal frictionless surface collides head on with a stationary 8.60 kg block. The 5.20 kg block rebounds at 1.80 m/s. How much kinetic energy is lost during this collision? **(7 marks)**

10. A 250 kg roller coaster car travels past points A and B with speeds shown in the diagram below. How much heat energy is produced between these points? **(7 marks)**



11. Two gliders having equal masses, each travelling along a level frictionless track at the same speed, approach each other head on. They stick together on impact and remain stationary at the point of impact. Does this situation mean that momentum has been lost during this particular collision? State your answer with supporting arguments which use principles of physics. **(4 marks)**

12. Two students throw identical tennis balls towards a building at the same speed. One ball strikes the wall, bouncing back at half its original speed. The other ball smashes a window and continues in the same direction at half its original speed. Did the two tennis balls experience the same impulse when in contact with the wall and the window? Justify your answer using principles of physics. **(4 marks)**

ENERGY & MOMENTUM
PROVINCIAL EXAMINATION ASSIGNMENT
ANSWER KEY / SCORING GUIDE

PART A: Multiple Choice (each question worth ONE mark)

Q	K
1.	B
2.	A
3.	D
4.	D
5.	A
6.	B
7.	A
8.	D
9.	A
10.	A
11.	B
12.	A
13.	D
14.	D
15.	C
16.	C
17.	B
18.	B
19.	D
20.	A
21.	C
22.	A
23.	D
24.	C
25.	B
26.	B
27.	C
28.	C
29.	B
30.	C
31.	D
32.	C
33.	B

1. A 0.030 kg toy car is pushed back against a spring-based launcher as shown in Diagram 1.

Diagram 1

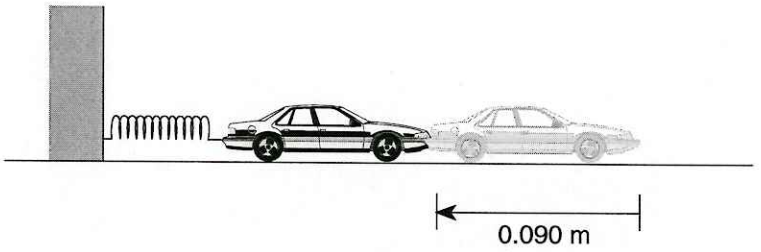
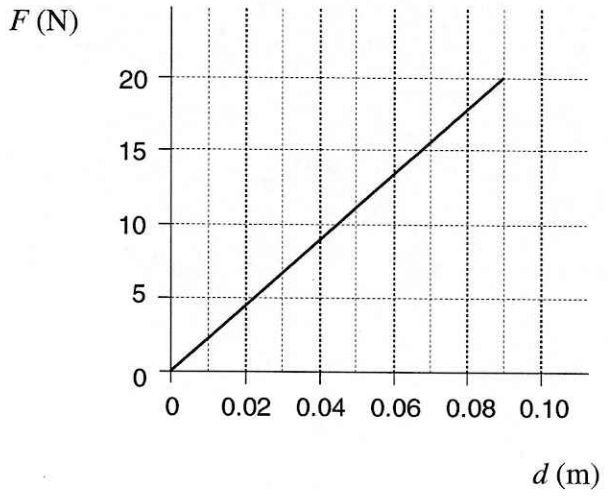


Diagram 2 shows a graph of the force required to compress the spring 0.090 m.

Diagram 2



a) What is the work done in compressing the spring? **(3 marks)**

Suggestion: Allow 1 to 3 sig figs for all parts of question 2.

W = *Area under graph*

$= \frac{1}{2}(0.09\ \text{m})(20\ \text{N})$

$= 0.90\ \text{N}\cdot\text{m}\quad (0.90\ \text{J})$ ← **3 marks**

(Will accept 0.9 J)

b) Assuming no losses due to heat, what maximum speed is reached by the toy car when it is released? **(3 marks)**

$$W = \Delta E_k$$

$$\therefore \Delta E_k = 0.90 \text{ J}$$

$$\therefore \frac{1}{2} m v_{\max}^{\ 2} = 0.90 \text{ J}$$

$$\therefore v_{\max} = \left(\frac{2 \cdot 0.90 \text{ J}}{0.030 \text{ kg}} \right)^{\frac{1}{2}}$$

$$= 7.7 \text{ m/s} \quad \leftarrow \textbf{3 marks}$$

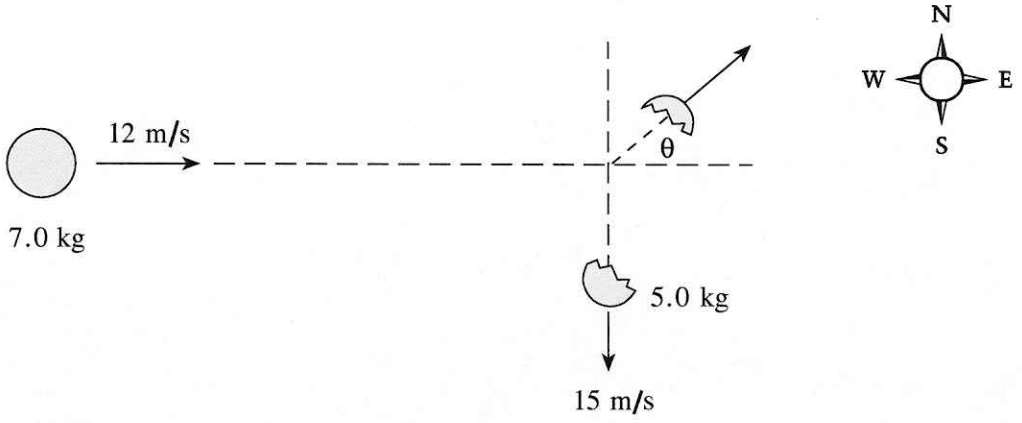
c) If in fact the maximum kinetic energy of the car is 0.18 J, what is the efficiency of the spring-based launcher? **(1 mark)**

$$Efficiency = \frac{Energy\ out}{Energy\ in} \times 100$$

$$\therefore Efficiency = \frac{0.18 \text{ J}}{0.90 \text{ J}} \times 100 = 20\% \quad \leftarrow \textbf{1 mark}$$

(Accept 0.2)

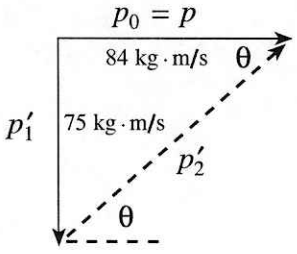
2. A 7.0 kg object moving at 12 m/s to the east explodes into two unequal fragments. The larger 5.0 kg fragment moves at 15 m/s south.



What is the velocity (speed and direction) of the smaller 2.0 kg fragment? **(7 marks)**

$p_0 = p$

$p_0 = m_0 v_0 = 7.0(12) = 84 \text{ kg} \cdot \text{m/s}$ } ← **1 mark for isolation**



$p_2' = (p_1')^2 + (p_0')^2$

$= 75^2 \text{ kg} \cdot \text{m/s}^2 + 84^2 \text{ kg} \cdot \text{m/s}^2$ ← **3 marks**

$p_2' = 113 \text{ kg} \cdot \text{m/s}$ ← **1 mark**

$v_2' = \frac{p_2'}{m_2} = \frac{113}{2.0} = 56 \text{ m/s}$ ← **1 mark**

$\frac{\sin\theta}{75} = \frac{\sin 90}{113} \quad \therefore \theta = 42° \text{ N of E}$

$\tan\theta = \frac{75}{84} \quad \therefore \theta = 42° \text{ N of E}$ } ← **either one for 1 mark**

Component Method:

x: $\quad m_0 v_{0x} = m_1 v_{1x}' + m_2 v_{2x}'$

$$(7\text{ kg})(12\text{ m/s}) = (5\text{ kg})(0\text{ m/s}) + (2\text{ kg})\left(v_{2x}'\right)$$

$$v_{2x}' = 42\text{ m/s} \qquad \leftarrow \textbf{2 marks}$$

y: $\quad m_0 v_{0y} = m_1 v_{1y}' + m_2 v_{2y}'$

$$(7\text{ kg})(0\text{ m/s}) = (5\text{ kg})(-15\text{ m/s}) + (2\text{ kg})\left(v_{2y}'\right)$$

$$v_{2y}' = 37.5\text{ m/s} \qquad \leftarrow \textbf{2 marks}$$

$$\left(v_2'\right)^2 = \left(v_{2x}'\right)^2 + \left(v_{2y}'\right)^2$$

$$= (42\text{ m/s})^2 + (37.5\text{ m/s})^2$$

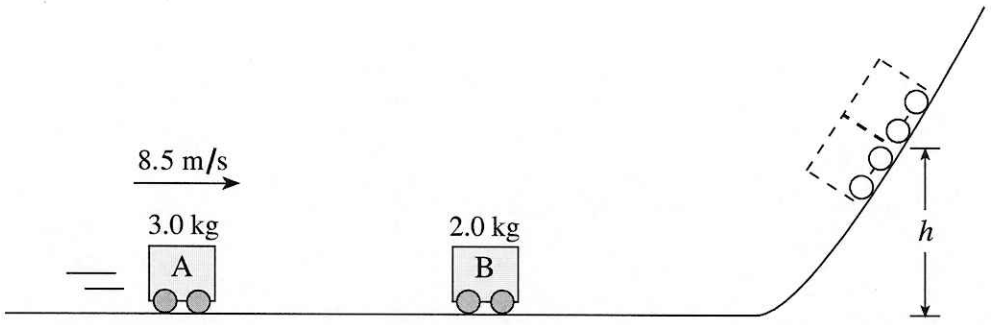
$$v_2' = 56.3\text{ m/s} \qquad \leftarrow \textbf{2 marks}$$

$$\tan\theta = \frac{v_{2y}'}{v_{2x}'}$$

$$= \frac{37.5\text{ m/s}}{42\text{ m/s}}$$

$$\theta = 42^\circ\text{ N of E} \qquad \leftarrow \textbf{1 mark}$$

3. A 3.0 kg car A travelling 8.5 m/s on a frictionless track collides and sticks on to a stationary 2.0 kg car B.



a) The combined cars will reach what height h? **(5 marks)**

$P_0 = P_f$

$(3.0)(8.5)+(2.0)(0) = (5.0)v$ ← **2 marks**

$v = 5.1$ m/s

$E_{T_0} = E_{T_f}$

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}(5.0)(5.1)^2 = (5.0)(9.8)h$ ← **3 marks**

$h = 1.3$ m