Neap:

PHYSICS VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2017

TEST 5: HOW FAST CAN THINGS GO? (II)

SUGGESTED SOLUTIONS AND MARKING SCHEME

Question 1 (23 marks)

a. Let right be positive.

$\vec{P}_{\text{total}} = (300 \times 2.4) + (250 \times -1.8)$

$= 720 + (-450)$ 1 mark

$= 270$ Ns 1 mark

right 1 mark

b. In the absence of external forces such as friction that would transfer momentum to the Earth, 1 mark

the total momentum of the dodgem cars is constant prior, during, and after the collision. 1 mark

c. $\vec{P}_{\text{total after}} = (300 \times -1.0) + (250 \times v_2)$ 1 mark

$-300 + 250v_2 = 270$

$250v_2 = 570$

$v_2 = 2.28 \text{ m s}^{-1}$ 1 mark

right 1 mark

d. impulse on dodgem car 1 = change in momentum of dodgem car 1

$= (300 \times -1.5) - (300 \times 2.4)$ 1 mark

$= 1170$ Ns 1 mark

e. $F_{\text{average}} = \dfrac{\text{impulse}}{\text{collision time}}$

$= \dfrac{1170}{0.100}$ 1 mark

$= 11\ 170$ N 1 mark

Note: Consequential on answer to ***Question 1d.***

f. total momentum = 270

$= (300 + 250)\ V_c$ 1 mark

$V_c = \dfrac{270}{550}$

$= 0.49\ \text{m s}^{-1}$ 1 mark

right 1 mark

Note: Consequential on answer to ***Question 1a.***

g. total inital kinetic energy $= \left(\frac{1}{2} \times 300 \times 2.0^2\right) + \left(\frac{1}{2} \times 250 \times 2.0^2\right)$

$= 600 + 500$

$= 1100\ \text{J}$ 1 mark

total final kinetic energy $= \left(\frac{1}{2} \times 300 \times 1.0^2\right) + \left(\frac{1}{2} \times 250 \times 1.6^2\right)$

$= 150 + 320$

$= 470\ \text{J}$ 1 mark

Since the total kinetic energy after the collision is less than that before the collision, it is an inelastic collision. 1 mark

The difference in kinetic energy has gone to heat and sound (and possibly some plastic deformation in the bumpers). 1 mark

h. Bumpers increase the collision time. 1 mark

Given that the change in momentum of each vehicle remains constant, and 1 mark

that $\text{average force} = \dfrac{\text{change in momentum}}{\text{collision time}}$, 1 mark

the force of impact is reduced. 1 mark

OR

Bumpers increase the collision distance. 1 mark

Given that the change in kinetic energies of the cars remains the same in the collision 1 mark

and $\text{average force} = \dfrac{\text{change in kinetic energy}}{\text{collision distance}}$, 1 mark

the average force of impact is reduced. 1 mark

Question 2 (5 marks)

a. work done = force × distance × $\cos(\theta)$

$= 3000 \times 10 \times \cos 0°$ 1 mark

$= 30\ 000\ \text{J}$ 1 mark

b. work done = area beneath force – distance graph

= number of squares × area of 1 square

$= 13.3 \times 100 \times 0.1 \times 10^6$ 2 marks

Note: Allow ± 0.5 of a square.

$= 1.33 \times 10^8\ \text{J}$ 1 mark

Question 3 (3 marks)

total mechanical energy (bottom) = total mechanical energy (top)

$$(E_K + E_g)_{bottom} = (E_K + E_g)_{top}$$

$$\left(\frac{1}{2} \times 65 \times 8.0^2\right) + (65 \times 10 \times 1.0) = \left(\frac{1}{2} \times 65 \times v^2\right) + (65 \times 10 \times 2.15)$$

$$2080 + 650 = 32.5v^2 + 1397.5 \quad \text{1 mark}$$

$$v^2 = \frac{1332.5}{32.5} \quad \text{1 mark}$$

$$v = 6.4 \text{ m s}^{-1} \quad \text{1 mark}$$

Question 4 (14 marks)

a. $k = \frac{F}{\Delta x}$

$= \frac{30}{0.10}$ 1 mark

$= 300 \text{ N m}^{-1}$ 1 mark

b. $F = k \times (\Delta x)$

$= 300 \times 0.30$ 1 mark

$= 90 \text{ N}$ 1 mark

c. $E = \frac{1}{2}k(\Delta x)^2$

$= \frac{1}{2} \times 300 \times 0.20^2$ 1 mark

$= 6.0 \text{ J}$ 1 mark

d. work done = energy stored

$= 6.0 \text{ J}$ 1 mark

Note: Consequential on answer to ***Question 4c.***

e. total mechanical energy initial = total mechanical energy final

$$6.0 = \frac{1}{2} \times 0.030 \times v^2 \quad \text{1 mark}$$

$$v = \sqrt{\frac{12}{0.030}} \quad \text{1 mark}$$

$$v = 20 \text{ m s}^{-1} \quad \text{1 mark}$$

Note: Consequential on answer to ***Question 4c.***

f. $\frac{1}{2}mv^2$ converts to mgh

$6.0 = 0.030 \times 10 \times h$ 1 mark

$h = 20 \text{ m}$ 1 mark

Note: Consequential on answer to ***Question 4c.***

g. Air resistance acts on the ball as it moves upwards. 1 mark

The air resistance converts some of the kinetic energy of the ball to heat and sound reducing the amount available for gravitational potential energy. 1 mark