
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.

$$\begin{aligned}\vec{P}_{\text{total}} &= (300 \times 2.4) + (250 \times -1.8) \\ &= 720 + (-450) \\ &= 270 \text{ Ns}\end{aligned}$$

1 mark

1 mark

right

1 mark

- b. In the absence of external forces such as friction that would transfer momentum to the Earth,
the total momentum of the dodgem cars is constant prior, during, and after the collision.

1 mark

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

$$= 1170 \text{ Ns}$$

1 mark

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

$$= \frac{1170}{0.100}$$

1 mark

$$= 11\,700 \text{ N}$$

1 mark

Note: Consequential on answer to Question 1d.

f. total momentum = 270

$$= (300 + 250) V_c \quad 1 \text{ mark}$$

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

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

right

1 mark

Note: Consequential on answer to Question 1a.

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

$$= 600 + 500$$

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

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

$$= 150 + 320$$

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

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 average force = $\frac{\text{change in momentum}}{\text{collision time}}$, 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 average force = $\frac{\text{change in kinetic energy}}{\text{collision distance}}$, 1 mark

the average force of impact is reduced. 1 mark

Question 2 (5 marks)

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

$$= 3000 \times 10 \times \cos 0^\circ \quad 1 \text{ mark}$$

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

b. work done = area beneath force – distance graph

$$= \text{number of squares} \times \text{area of 1 square}$$

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

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

2 marks
Note: Allow ± 0.5 of a square.
1 mark

Question 3 (3 marks)

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

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

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

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

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

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

Question 4 (14 marks)

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

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

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

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

$$= 300 \times 0.30 \quad 1 \text{ mark}$$

$$= 90 \text{ N} \quad 1 \text{ mark}$$

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

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

$$= 6.0 \text{ J} \quad 1 \text{ mark}$$

d. work done = energy stored

$$= 6.0 \text{ J} \quad 1 \text{ mark}$$

Note: Consequential on answer to Question 4c.

e. total mechanical energy initial = total mechanical energy final

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

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

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

Note: Consequential on answer to Question 4c.

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

$$6.0 = 0.030 \times 10 \times h \quad 1 \text{ mark}$$

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

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