
PHYSICS VCE UNITS 3&4 DIAGNOSTIC TOPIC TESTS 2017

TEST 4: HOW FAST CAN THINGS GO? (I)

SUGGESTED SOLUTIONS AND MARKING SCHEME

Question 1 (9 marks)

a. **vertical + : $a = -10$**

up is +

$$V_{\text{top}} = 0$$

$$u_v = u \sin 30^\circ$$

horizontal $\rightarrow$ + : $S_{\text{horizontal}} = 60 \text{ m}$

$$V_{\text{horizontal}} = u \cos 30^\circ$$

vertically: $V_{\text{top}} = u \sin 30 - \frac{u \sqrt{3}}{10 t^2}$

$$0 = \frac{u}{2} - 10 t_{\text{top}}$$

horizontally: $S_{\text{horizontal}} = V_{\text{horizontal}} \times t_{\text{air}}$

$$60 = \frac{u \sqrt{3}}{2} \times t_{\text{air}}$$

$$0 = \frac{u}{2} - 10 t_{\text{top}} \Rightarrow u = 20 t_{\text{top}} \text{ and } t_{\text{top}} = \frac{1}{2} t_{\text{air}} \quad 1 \text{ mark}$$

Since $60 = \frac{u \sqrt{3}}{2} \times t_{\text{air}}$, substitute for u with $u = 10 t_{\text{air}}$.

$$60 = 10 t_{\text{air}} \frac{\sqrt{3}}{2} \times t_{\text{air}} \quad 1 \text{ mark}$$

$$t_{\text{air}}^2 = \frac{12}{\sqrt{3}}$$

$$t_{\text{air}} = 2.63 \text{ sec} \quad 1 \text{ mark}$$

b. $S_{\text{horizontal}} = V_{\text{horizontal}} \times t_{\text{air}}$

$$60 = \frac{u\sqrt{3}}{2} \times t_{\text{air}}$$

1 mark

$$u = \frac{120}{\sqrt{3}t_{\text{air}}}$$

$$= \frac{120}{\sqrt{3} \times 2.63}$$

$$= 26.3 \text{ m s}^{-1}$$

1 mark

Note: Consequential on answer to Question 1a.

c. **vertically:** $V_{\text{top}}^2 = U_V^2 + 2as$

$$0 = (26.3 \sin 30)^2 + 2(-10)(s)$$

1 mark

$$s = \frac{(26.3 \times 0.5)^2}{20}$$

$$= 8.64 \text{ m}$$

1 mark

Note: Consequential on answer to Question 1b.

- d. At the speed which the motorcyclist is travelling, the air resistance is significant enough to reduce the forward motion such that the motorcycle would land short of 60 m.

1 mark

Thus, travelling at a higher take-off speed, after the loss of energy due to air resistance is accounted for, this would allow a minimum energy to reach the bank on the other side.

1 mark

Question 2 (7 marks)

a. $F_{\text{net}} = ma$

$$= 1000 \times -1.0$$

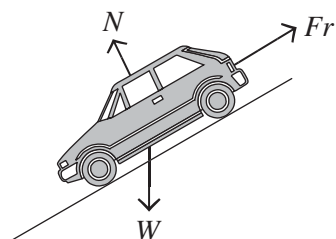
1 mark

$$= -2000 \text{ N}$$

$$\text{magnitude} = 2000 \text{ N}$$

1 mark

b.



$$\Sigma \vec{F} = ma$$

$$W \sin 30 - Fr_{\text{brakes}} = ma$$

1 mark

$$\left(1000 \times 10 \times \frac{1}{2}\right) - Fr_{\text{brakes}} = 1000 \times -1$$

1 mark

$$Fr_{\text{brakes}} = 6000 \text{ N}$$

1 mark

c. $\Sigma \vec{F} = m\vec{a}$

$$N - W \cos 30 = 0$$

1 mark

$$N = W \cos 30$$

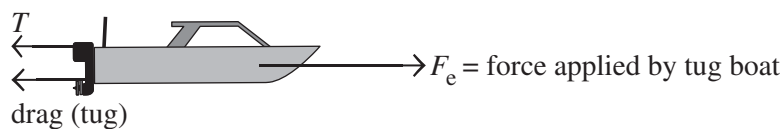
$$= 1000 \times 10 \times 0.866$$

$$= 8660 \text{ N}$$

1 mark

Question 3 (5 marks)

a.



$$\Sigma \vec{F} = m \times a$$

$$F_e - T - \text{drag (tug)} = m_{\text{tug}} \times a$$

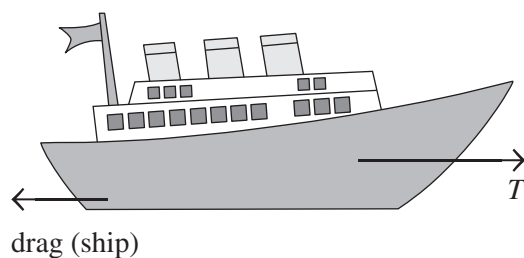
1 mark

$$10\,000 - T - 1000 = 1000 \times 1.0$$

$$T = 8000 \text{ N}$$

1 mark

b.



$$\Sigma \vec{F}_{\text{ship}} = m_{\text{ship}} a$$

$$T - \text{drag} = m_{\text{ship}} a$$

1 mark

$$8000 - 2000 = m_{\text{ship}} \times 1.0$$

1 mark

$$8000 - 2000 = m_{\text{ship}}$$

$$m_{\text{ship}} = 6000 \text{ kg}$$

1 mark

*Note: Consequential on answer to **Question 3a**.*

Question 4 (8 marks)

a. **D**

1 mark

Velocity is tangential and left (west). Acceleration and centripetal force are south.

b. $F_c = \frac{mv^2}{r}$

$$= \frac{1000 \times 20^2}{100}$$

1 mark

$$= 4000 \text{ N}$$

1 mark

c. force = 4000 N

1 mark

Note: Consequential on answer to Question 4b.

The centripetal force is provided by the road–tyre friction pointing radially inwards.

1 mark

d. vertically: $\Sigma \vec{F} = 0$

$$R \cos \theta = mg$$

horizontally: $\Sigma \vec{F} = \frac{mv^2}{r}$

$$R \sin \theta = \frac{mv^2}{r}$$

combining the two equations, $\tan \theta = \frac{v^2}{r \times g}$

1 mark

$$\theta = \tan^{-1} \left(\frac{20^2}{100 \times 10} \right)$$

1 mark

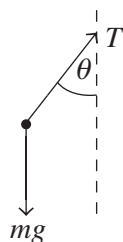
$$\theta = \tan^{-1}(0.4)$$

$$= 22^\circ$$

1 mark

Question 5 (16 marks)

a.



$$\Sigma \vec{F} = \vec{0}$$

$$T \cos \theta - mg = 0$$

1 mark

$$T = \frac{0.100 \times 10}{\cos 30^\circ}$$

$$= 1.15 \text{ N}$$

1 mark

b. $F_{\text{net}} = \frac{mv^2}{r}$

$$= T \sin \theta$$

$$= 1.15 \times \sin 30^\circ$$

1 mark

$$= 0.58 \text{ N}$$

1 mark

Note: Consequential on answer to Question 5a.

c. $F_{\text{net}} = 0.58$

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

$$r = L \times \sin 30^\circ$$

$$\frac{0.100 \times v^2}{1.0 \sin 30^\circ} = 0.58$$

1 mark

$$v = \sqrt{\frac{0.58 \times 0.5}{0.100}}$$

$$= 1.70 \text{ m s}^{-1}$$

1 mark

Note: Consequential on answer to Question 5b.

d. $v = \frac{2\pi r}{T}$

$$T = \frac{2\pi r}{v}$$

$$T = \frac{2\pi \times 1.0 \sin 30}{1.70}$$

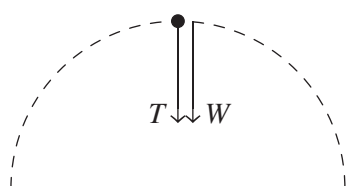
1 mark

$$T = 1.85 \text{ s}$$

1 mark

Note: Consequential on answer to Question 5c.

e.



$$\Sigma \vec{F} = \frac{mv^2}{r}$$

$$T + W = \frac{mv^2}{r}$$

1 mark

$$2mg = \frac{mv^2}{r}$$

$$v = \sqrt{2rg}$$

$$= \sqrt{2 \times 1.0 \times 10}$$

1 mark

$$= 4.47 \text{ m s}^{-1}$$

1 mark

f. $T + W = \frac{mv^2}{r}$

At v_{min} , $T = 0$

$$\therefore mg = \frac{mv^2}{r}$$

$$v = \sqrt{rg}$$

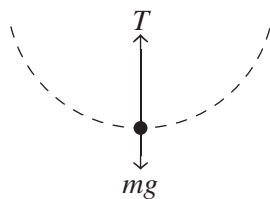
$$v = \sqrt{1.0 \times 10}$$

1 mark

$$= 3.16 \text{ m s}^{-1}$$

1 mark

g.



$$\Sigma \vec{F} = \frac{mv^2}{r}$$

$$T - mg = \frac{mv^2}{r}$$

$$2mg - mg = \frac{mv^2}{r}$$

1 mark

$$\therefore mg = \frac{mv^2}{r}$$

$$v = \sqrt{rg}$$

$$= \sqrt{1.0 \times 10}$$

1 mark

$$= 3.16 \text{ m s}^{-1}$$

1 mark