Neap:

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 +

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

$$u_v = u\sin 30°$$

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

$$V_{\text{horizontal}} = u\cos 30°$$

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

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

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

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

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

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

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

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

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

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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)

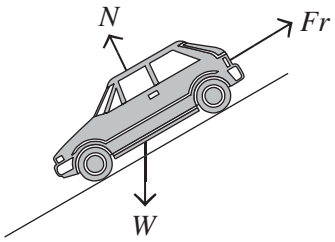
a. $F_{\text{net}} = ma$

$$= 1000 \times -1.0$$ 1 mark

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

magnitude = 2000 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

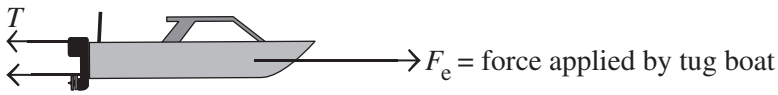
$N = W\cos 30$

$= 1000 \times 10 \times 0.866$

$= 8660$ N 1 mark

Question 3 (5 marks)

a.



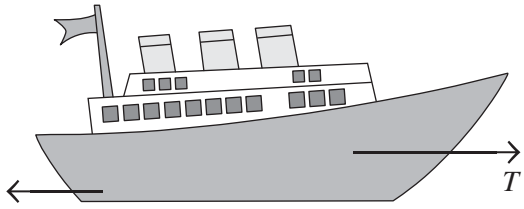
$\Sigma\vec{F} = m \times a$

$F_e - T - \text{drag (tug)} = m_{tug} \times a$ 1 mark

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

$T = 8000$ N 1 mark

b.



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

$T - \text{drag} = m_{ship}a$ 1 mark

$8000 - 2000 = m_{ship} \times 1.0$ 1 mark

$8000 - 2000 = m_{ship}$

$m_{ship} = 6000$ 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. $F_c = \dfrac{mv^2}{r}$

$= \dfrac{1000 \times 20^2}{100}$ 1 mark

$= 4000$ 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:** $\Sigma\vec{F} = 0$

$$R\cos\theta = \text{mg}$$

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

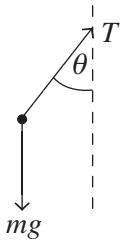
$$\theta = \tan^{-1}\left(\frac{20^2}{100 \times 10}\right)$$ 1 mark

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

$$= 22°$$ 1 mark

Question 5 (16 marks)

a.



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

$T\cos\theta - mg = 0$ 1 mark

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

$$= 1.15 \text{ N}$$ 1 mark

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

$$= T\sin\theta$$

$$= 1.15 \times \sin 30°$$ 1 mark

$$= 0.58 \text{ N}$$ 1 mark

*Note: Consequential on answer to **Question 5a.***

c.

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

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

$$r = L \times \sin 30°$$

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

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

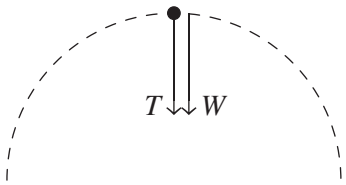
$$T = \frac{2\pi r}{v}$$

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

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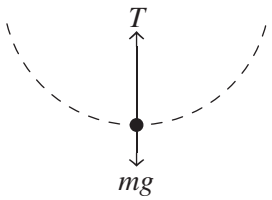
g.



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

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

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