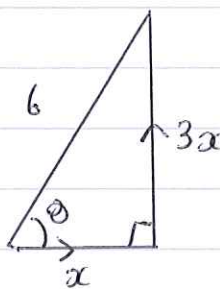
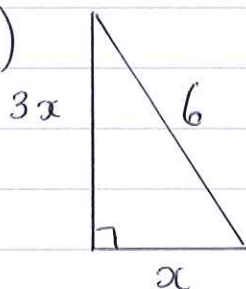


Mechanics - June 2009 Miss Watson's solutions

1 (i)



$$x^2 + (3x)^2 = 6^2$$

$$10x^2 = 36$$

$$x = \sqrt{\frac{36}{10}}$$

$$x = 1.897366596$$

$$x = 1.90$$



3

(ii) $\tan \theta = \frac{3x}{x}$

$$\theta = \tan^{-1}(3)$$

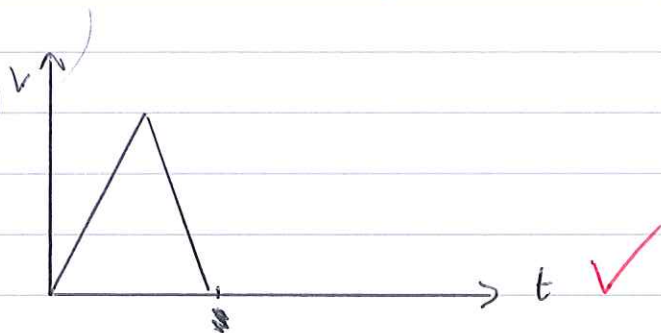
$$\theta = 71.565$$

$$\theta = 71.6^\circ$$



3

2 (i)



2

(ii) ~~scribbled out text~~

$$s = \frac{b \times h}{2}$$

$$6 = \frac{3 \times v}{2}$$

~~scribbled out text~~

$$s = \frac{1}{2}(v \times t)$$

~~scribbled out text~~

$$v = 4 \text{ ms}^{-1}$$

$$6 = \frac{1}{2}(v \times 3)$$

~~scribbled out text~~

maximum speed = 4 ms^{-1}

3

(iii) ~~scribbled out text~~

~~scribbled out text~~ $a = 2.4$ $n = 0$ $r = 4$ $s = ?$ or $t = ?$ *deceleration of 3*

$$r = ntat$$

$$3 - \frac{5}{3} = \frac{4}{3}$$

$$4 = 0 + 2.4 \times t$$

$$n = 4$$
 $v = 0$ $t = \frac{4}{3}$ $a = ?$

$$t = \frac{5}{3}$$

$$0 = 4 + \frac{4}{3}a$$
 $a = -3$

4

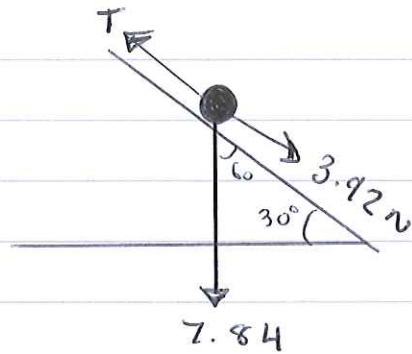
3

(i)

~~XXXXXXXXXXXXXXXXXXXX~~

$$0.8 \times 9.8 = 7.84$$

$$7.84 \times \cos 60 = 3.92$$



~~XXXXXXXXXX~~

~~XXXXXXXXXX~~

~~XXXXXXXXXX~~

~~XXXXXXXXXXXXXXXXXXXX~~

$$F = ma$$

$$3.92 - T = 0.8 \times 0.2$$

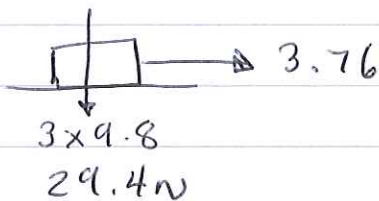
$$3.92 - 0.16 = T$$

$$3.76 = T$$



4

(ii)



$$T - f_{lim} = 3 \times 0.2$$

$$3.76 - \mu \times 29.4 = 0.6$$

$$\frac{3.76 - 0.6}{29.4} = \mu$$

$$\mu = 0.10748209$$

$$\mu = 0.107$$



5

4

(i) $u = 7$ $a = -9.8$ $s = 2.1$ $v = ?$

$$v^2 = u^2 + 2as$$

$$v^2 = 7^2 + 2 \times -9.8 \times 2.1$$

$$v = 2.8 \text{ ms}^{-1}$$



3

(ii) $u = 7$ $v = 0$ $s = ?$ $a = -9.8$

$$0 = 7^2 + 2 \times -9.8 \times s$$

$$\frac{-49}{-19.6} = s = 2.5 \text{ m}$$



3

could do this in one go

$u = 7$ $v = -5.7$
 $a = -9.8$
 $t = ?$

(iii) $u = 0$ $v = 5.7$ $t = ?$ $a = 9.8$

$$v = u + at$$

$$5.7 = 0 + 9.8 \times t$$

$$t = \frac{5.7}{9.8}$$

$u = 7$ $v = 0$ $t = ?$ $a = -9.8$

$$v = u + at$$

$$0 = 7 + -9.8 \times t$$

$$t = \frac{5}{9.8}$$



$$t = 1.29591 \approx 1.30 \text{ s}$$

3

5

(i) $mv = 0.5 \times 6 = 3$

$0.5v + \cancel{mv} (v+1) \times m = 3$

$0.5v + mv + m = 3$

$mv + 0.5v = -m + 3$

$v(m + 0.5) = -m + 3$



3

(ii) $4m - 2 \times 0.5 = 4m - 1$ (momentum)

$mv + 0.5 \times (v+1) = 4m - 1$

$mv + 0.5v + 0.5 = 4m - 1$

~~mv + 0.5v + 0.5~~

$v(m + 0.5) = 4m - 1.5$

$a = 4$

$b = -1.5$



4

(iii) $v(m + 0.5) = -m + 3$

$v(m + 0.5) = 4m - 1.5$

$-m + 3 = 4m - 1.5$

$4.5 = 5m$

$m = 0.9$



$v(m + 0.5) = 4m - 1.5$

$v(0.9 + 0.5) = 4 \times 0.9 - 1.5$

$1.4v = 2.1$

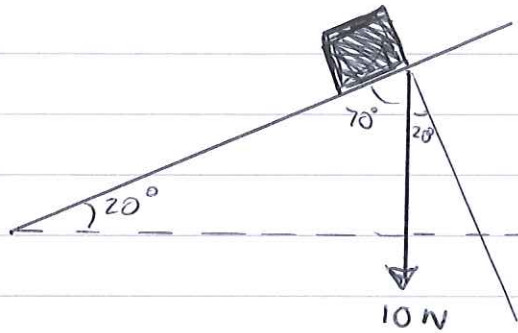
$v = 1.5$



4

6

(i) (a)



$$\begin{aligned} \text{Perp to plane} &= 10 \times \cos 20 = 9.396926 \\ &= 9.40 \text{ N} \quad \checkmark \end{aligned}$$

$$\begin{aligned} \text{Parallel to plane} &= 10 \times \cos 70 = 3.420201 \\ &= 3.42 \text{ N} \quad \checkmark \end{aligned}$$

2

(b) $F_{\text{lim}} = 3.42$ (because constant speed),

$$3.42 = \mu \times R$$

$$3.42 = \mu \times 9.4$$

$$\mu = 0.363851$$

$$= 0.364 \quad \checkmark$$

2

(ii) $T \cos 45 = \mu \times R + 3.42$ $R = 9.4 + T \cos 45$

$$T \cos 45 = 0.364(9.4 + T \cos 45) + 3.42$$

$$T \cos 45 = 6.8416 + 0.364 T \cos 45$$

$$T \cos 45 - 0.364 T \cos 45 = 6.8416$$

$$0.636 T \cos 45 = 6.8416$$

$$T = 15.21302438$$

$$= 15.2 \quad \checkmark$$

7

(7)

(i) $v = 6t - t^2$

$\frac{dv}{dt} = 6 - 2t$

$a = 6 - 2t$ ✓

2

(ii) $\int_0^3 6t - t^2 dt = \left[3t^2 - \frac{1}{3}t^3 \right]_0^3$

$= \left(3 \times 3^2 - \frac{3^3}{3} \right) - (0)$

$= 18m$ ✓

5

(iii) $100 - 18 = 82$

$b \times h = 82$

$b \times 9 = 82$

$t = 9.1$

+ 3

$t = \frac{109}{9} = 12.1 \text{ seconds}$ ✓

3

(iv) ~~$19 \times 9 = 189$~~ $19 \times 9 = 171$

~~$189 + 18 =$~~ $171 + 18 = 189$

$200 - 189 = 11$

$s = 11$ $u = 9$ $a = -0.6$ $t = 7$

~~$v^2 = u^2 + 2as$~~

~~$v^2 = 9^2 + 2 \times -0.6 \times 11$~~

~~$v^2 = 67.8$~~

~~$v = 8.234$~~

$s = ut + \frac{1}{2}at^2$

$11 = 9 \times t + \frac{1}{2} \times -0.6 \times t^2$

$0.3t^2 - 9t + 11 = 0$

$a = 0.3$
 $b = -9$
 $c = 11$

$\frac{9 \pm \sqrt{9^2 - 4 \times 0.3 \times 11}}{2 \times 0.3} = 28.7 \text{ or } 1.2765$

$\frac{9 \pm \sqrt{67.8}}{0.6}$

~~22~~ $22 + 1.2765 = 23.2765$

~~$= 23.2765$~~
 $= 23.3$ ✓

7