YEAR 2

APPLIED

- MECHANICS

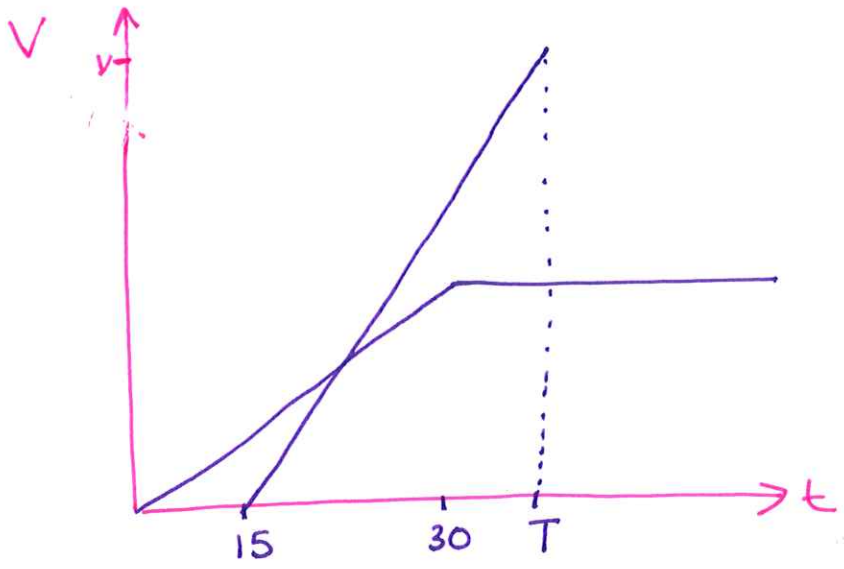
January 2019

Mock Paper

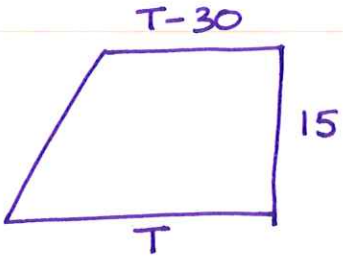
worked solutions

(1)

a)



b) car



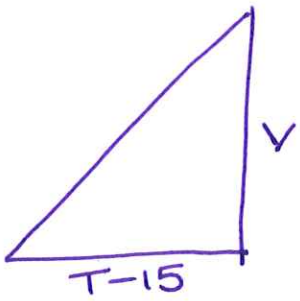
Distance Traveled

$= \frac{T-30+T}{2} \times 15$

$= \frac{2T-30}{2} \times 15$

$= 15T - 225$

Bike



Distance Traveled

$= \frac{1}{2}(T-15)V$

sub in $V = \frac{3}{2}(T-15)$

$= \frac{1}{2}(T-15)\frac{3}{2}(T-15)$

$= \frac{3}{4}(T-15)^2$

Acceleration = gradient

$1.5 = \frac{V}{T-15}$

$V = \frac{3}{2}(T-15)$

(1)

b cont.)

$$15T - 225 = \frac{3}{4}(T-15)^2$$

$$60T - 900 = 3(T-15)^2$$

$$20T - 300 = (T-15)^2$$

$$20T - 300 = T^2 - 30T + 225$$

$$0 = T^2 - 50T - 525$$

$$\therefore \quad T = 35$$

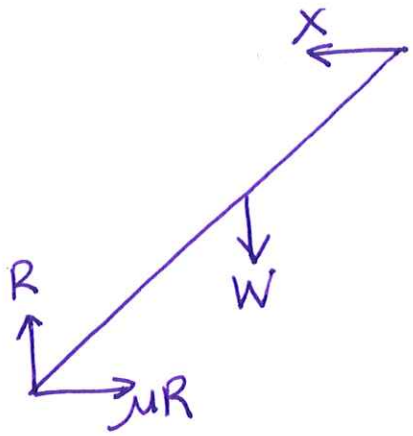
$$\text{speed} = \frac{3}{2}(T-15)$$

$$= \frac{3}{2}(20)$$

$$= 30$$

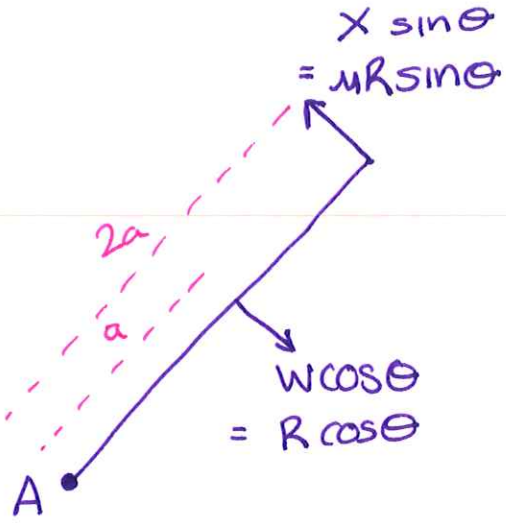
(2)

a)



$X = \mu R$

$R = W$



moments A

$$2a\mu R\sin\theta = Ra\cos\theta$$

$\div a \div R$

$$2\mu\sin\theta = \cos\theta$$

$$\mu = \frac{\cos\theta}{2\sin\theta}$$

$$\mu = \frac{1}{2\tan\theta}$$

b) mass position effects X which effects μ

closer to A smaller μ

closer ~~from~~ A larger μ

3

a) $r = (t^3 - 5t)\,i + (5t^2 + 6t)\,j$

differentiate ↓

$v = (3t^2 - 5)\,i + (10t + 6)\,j$

parallel to $i + 2j$ $\therefore$ gradient $= \frac{2}{1}$

$$\frac{10t + 6}{3t^2 - 5} = \frac{2}{1}$$

$$10t + 6 = 6t^2 - 10$$

$$0 = 6t^2 - 10t - 16$$

$$\therefore \quad T = \frac{8}{3}$$

b) $v = (3t^2 - 5)\,i + (10t + 6)\,j$

differentiate ↓

$a = 6t\,i + 10\,j$

$t = 2$

$a = 12i + 10j$

$F = ma$

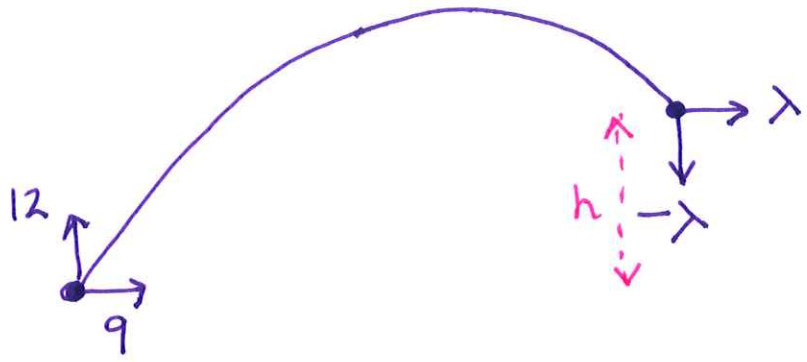
$F = 0.5(12i + 10j)$

$F = 6i + 5j$

Magnitude of $F = \sqrt{6^2 + 5^2} = 7.81$

(4)

a)



horizontial speed stays the same $\therefore \quad x = 9$

and $-x = -9$

Vertical motion

$s = h$

$u = 12$

$v = -9$

$a = -9.8$

$t =$

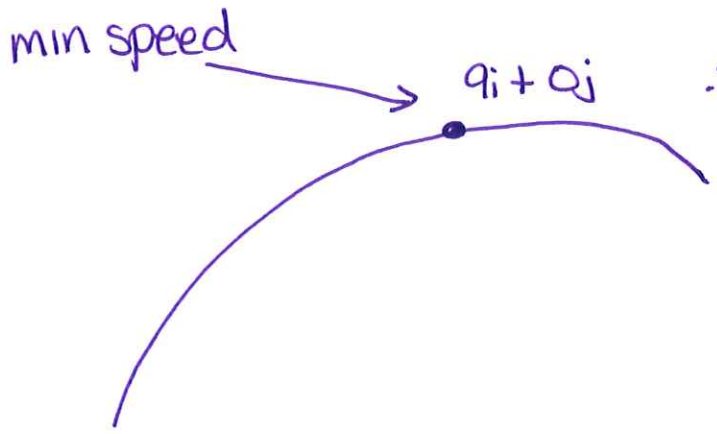
$v^2 = u^2 + 2as$

$(-9)^2 = (12)^2 + 2(-9.8)h$

$81 = 144 - 19.6h$

$h = 3.21$

b)

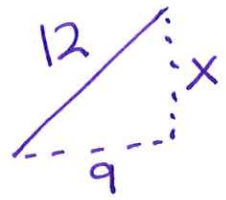


$\therefore$ speed $= \sqrt{9^2 + 0^2}$

$= 9$

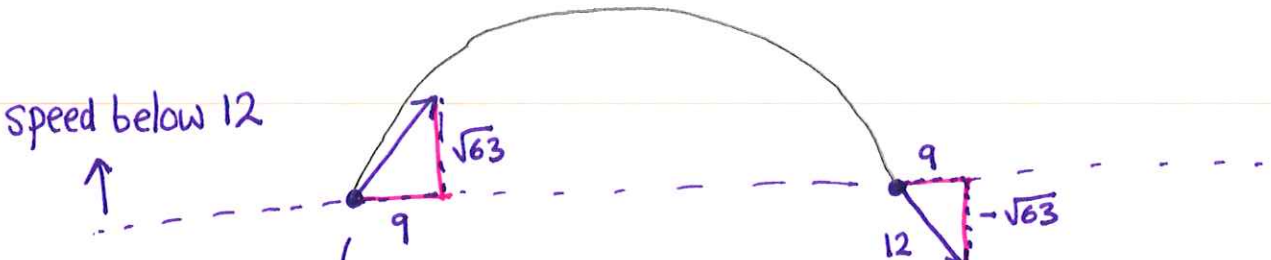
(4)

c) The vertical speed needed to give a resultant speed of 12:



$x = \sqrt{12^2 - 9^2}$

$= \sqrt{63}$



$v = u + at$

$\sqrt{63} = 12 - 9.8t$

$t = 0.41456$

$v = u + at$

$-\sqrt{63} = 12 - 9.8t$

$t = 2.0344$

time less than $12 ms^{-1}$

$2.0344 - 0.41456 = 1.62$

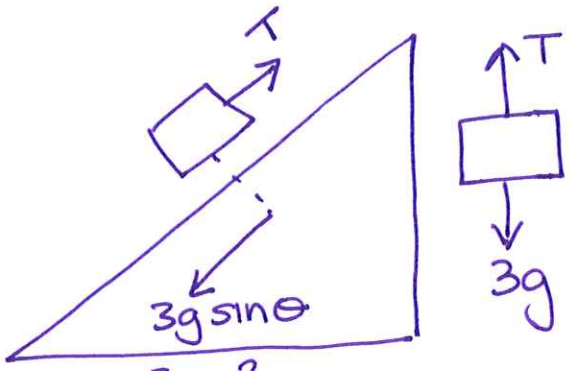
d) - rotational spin on ball

or

- dimensions of the ball

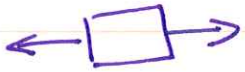
(5)

a)



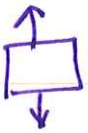
$= 3g \frac{2}{7}$

$= \frac{6g}{7}$



$F = ma$

$T - \frac{6g}{7} = 3a$



$F = ma$

$3g - T = 3a$

$$T - \frac{6g}{7} = 3g - T$$

×7

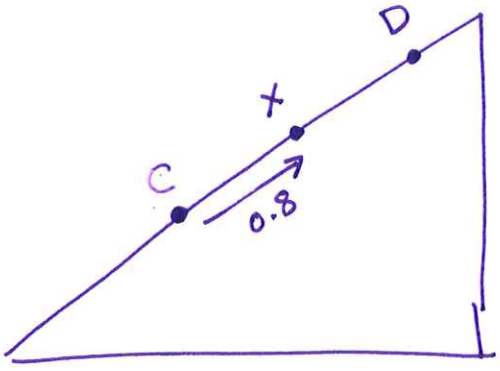
$$7T - 6g = 21g - 7T$$

$$14T = 27g$$

$$T = \frac{27g}{14} = 18.9$$

(5)

b)



C to X

Acceleration $3g - T = 3a$

$T = 18.9$

$\therefore \quad a = 3.5$

Speed at X $v^2 = u^2 + 2a$

$v^2 = 0^2 + 2(3.5)(0.8)$

$v^2 = 5.6$

X to D

X $u^2 = 5.6$ D $v = 0$

Acceleration $F = ma$

$0 - 3g\sin\theta = 3a$

$-\frac{6}{7}g = 3a$

$a = -\frac{2g}{7}$

(5)

b) conti X to D

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

$$0^2 = 5.6 + 2\left(-\frac{2g}{7}\right)s$$

$$s = 1$$

Total Distance = 0.8 + 1

= 1.8

c) - model takes no account of size of package

- if rope not inextensible cant assume equal acceleration