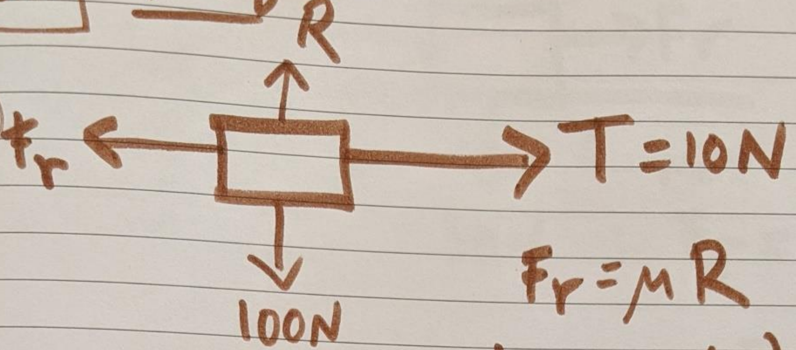
$\boxed{\text{Ex 8A}}$ P148

1 i

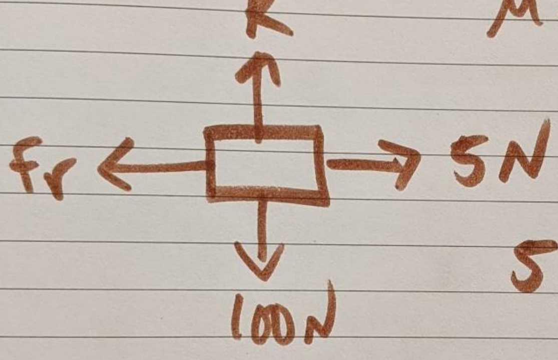



$F_r = \mu R$

$10 = \mu(100)$

$\mu = 1/100$

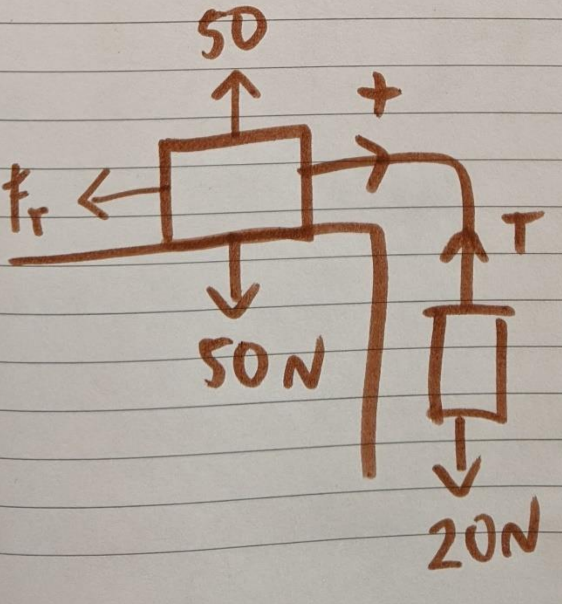
ii




$5 = \mu(100)$

$\mu = \frac{1}{20}$

2 i




Max

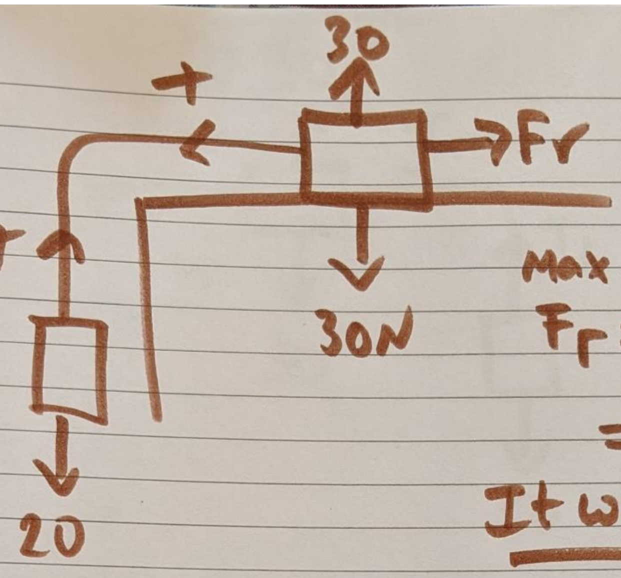
$F_r = \mu R$

$= \frac{1}{2}(50)$

$= 25$

$\boxed{\text{Will Not Move } F_r = 20}$

2ii




Max

$F_r = \frac{1}{4}(30)$

$= 7.5$

It will move!

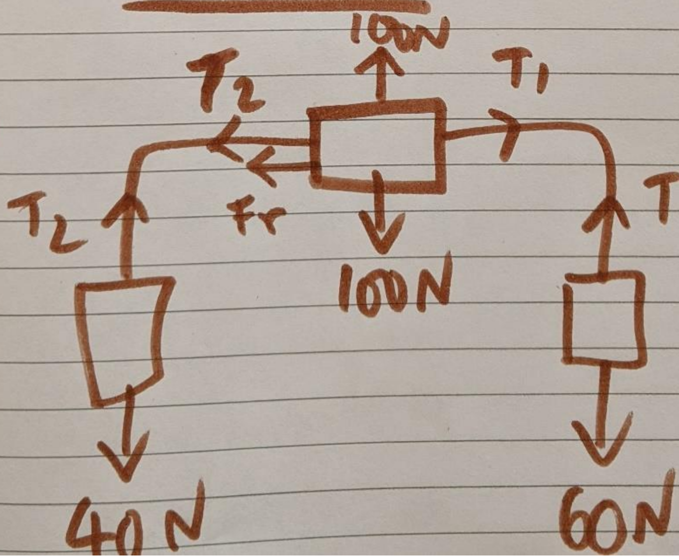
$20 - T = 2a$

$T - 7.5 = 3a$

$12.5 = 5a$

$a = 2.5\ ms^{-2}$

2iii




Max

$F_r = 0.3(100)$

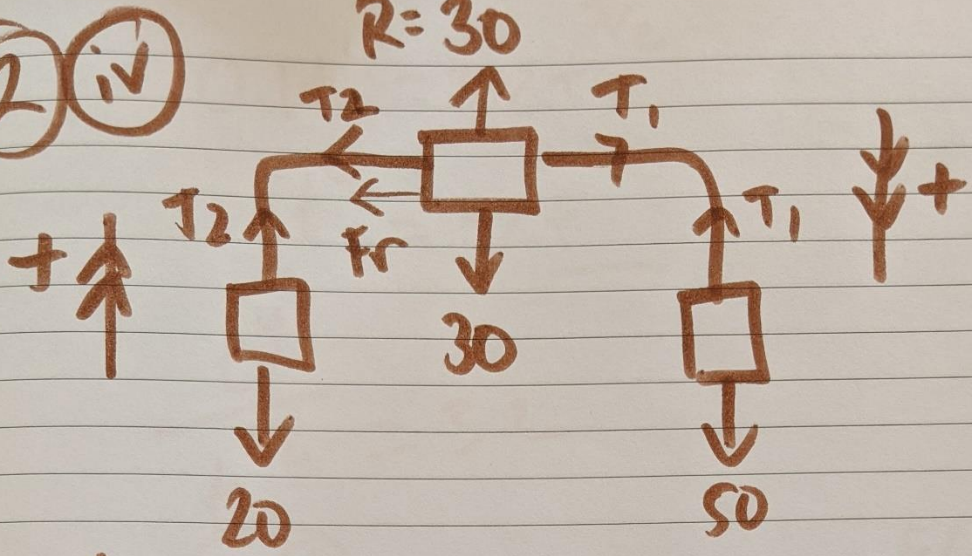
$= 30$

It won't move

$F_r = 60 - 40$

$= 20N$

2 iv




Max $Fr = \frac{1}{4}(30)$

$= 7.5N$

It will move!

$50 - T_1 = 5a$

$T_1 - T_2 - fr = 3a$

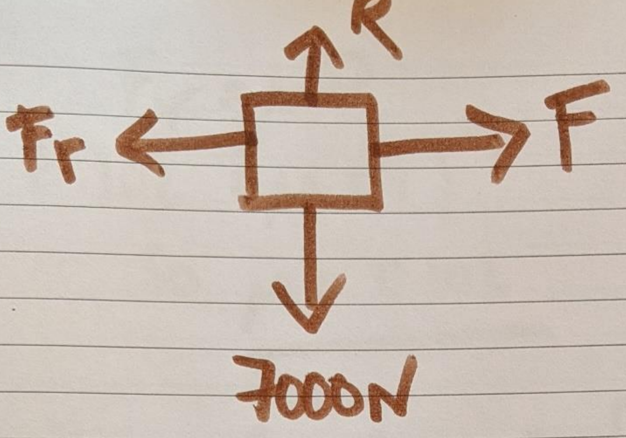
$T_2 - 20 = 2a$

$50 - 7.5 - 20 = 10a$

$22.5 = 10a$

$a = 2.25 \ ms^{-2}$

③



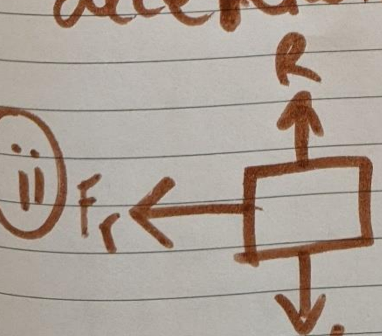

$F_r = 0.7\,(7000)$
$= 4900\text{ N}$ or $4.9\text{ kN}$

④ (i)

$s = 49$ | $v^2 = u^2 + 2as$
$u = 10$ | $0 = 100 + 98a$
$v = 0$ | $a = \underline{-1.02\ \text{ms}^{-2}}$
$a = ?$ | $\underline{(3SF)}$
$t$

deceleration $= \underline{+1.02\ \text{ms}^{-2}}$

(ii)




$+\rightarrow$

$-F_r = 0.1\,(\cancel{a}\ -1.02)$
$F_r = \underline{0.102\text{ N}}$ (3SF)

4iii

$F_r = \mu R$

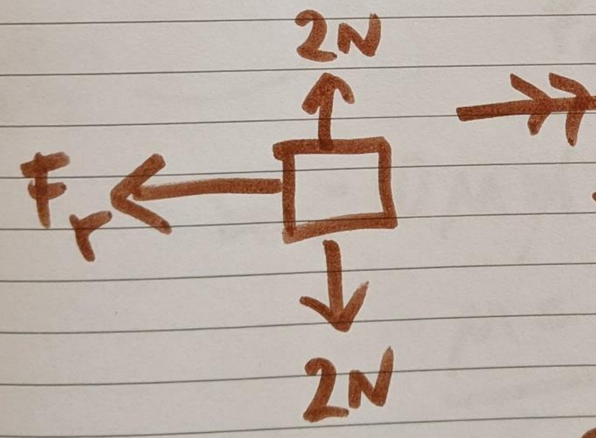
$0.102 = \mu(1)$

so $\underline{\mu = 0.102}$

4iv Using the same coefficient of friction

$F_r = 0.102(2)$

$= 0.204\ N$




$F = ma$

$-F_r = 0.2a$

$a = \frac{-0.204}{0.2}$

$a = -1.02$ !

same acceleration.

$s = ?$
$u = 10$
$v = 0$
$a = -1.02$
$t$

$0^2 = 100 + 2(-1.02)s$

$\underline{s = 49\,m}$

The same as the other piece of ice.

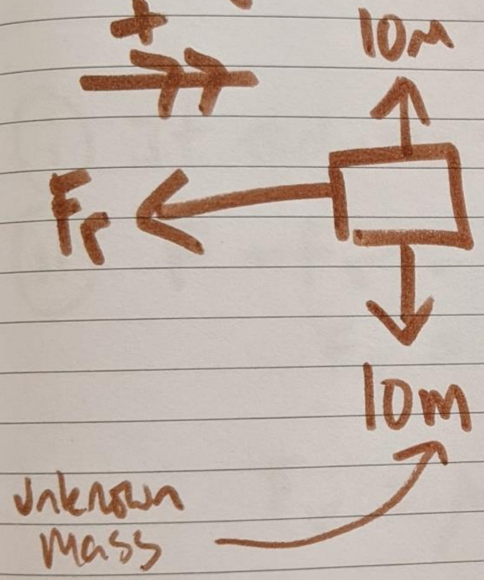
(5)

$s = 9$
$u = 12$
$v = 0$
$a = ?$
$t$

$$0^2 = 144 + 2a(9)$$

$$a = \frac{144}{-18}$$

$$a = -8\ ms^{-2}$$




$$\boxed{-F_r = ma}$$ Newton's 2nd law

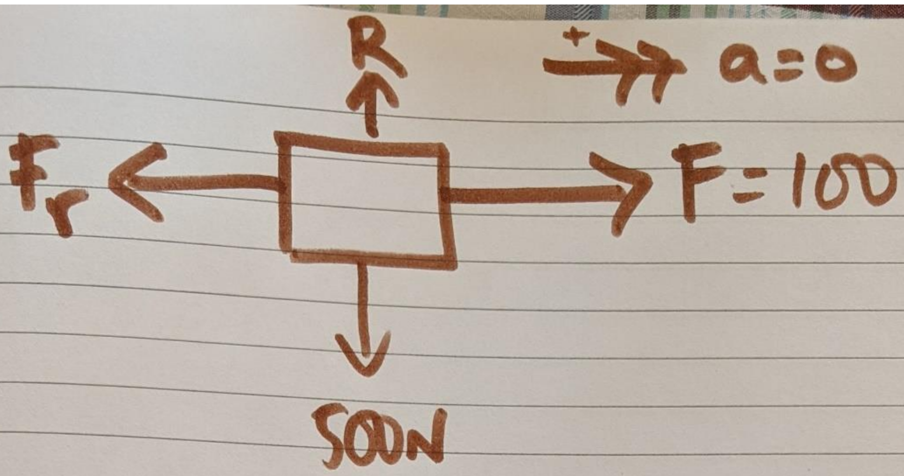
$$\boxed{F_r = \mu R}$$

$$F_r = \mu(10m)$$

So $-10\mu \cancel{m} = \cancel{m}(-8)$

$$\underline{\mu = 0.8}$$

(6)




(i) It reduces the frictional force.

(ii) $F - F_r = 0$

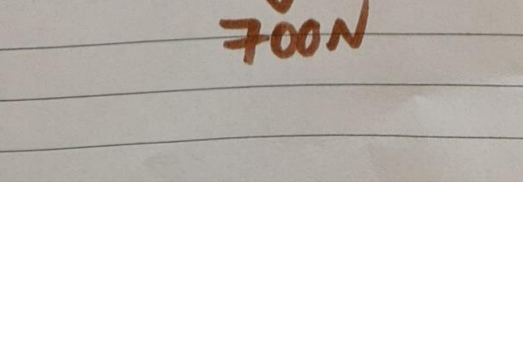
$F_r = 100N$

$F_r = \mu R$

$100 = \mu(500)$

$\mu = 0.2$

(iii)




$R = 700$

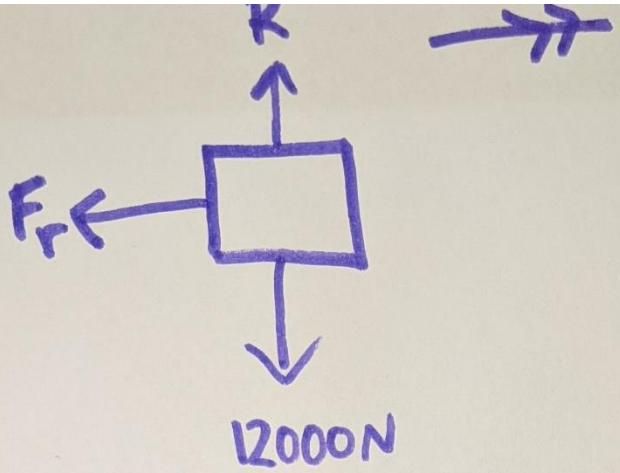
$F_r = 0.2(700)$

$= 140N$

so $F = 140N$

to get $a = 0$

7




i

$F_r = \mu R$

$F_r = 0.75(12000)$

$= 9000\,N$

$F = ma$

$-F_r = 1200a$

$\frac{-9000}{1200} = a$

$\underline{a = -7.5\,ms^{-2}}$

ii

$s = 40$
$u = 30$
$v = ?$
$a = -7.5$
$t$

$v^2 = 30^2 + 2(-7.5)(40)$

$\underline{v = 10\sqrt{3}\,ms^{-1}}$

iii

$s = ?$
$u = 10\sqrt{3}$
$v = 0$
$a = -8$
$t$

New acceleration

$F_r = 0.8(12000)$

$= 9600\,N$

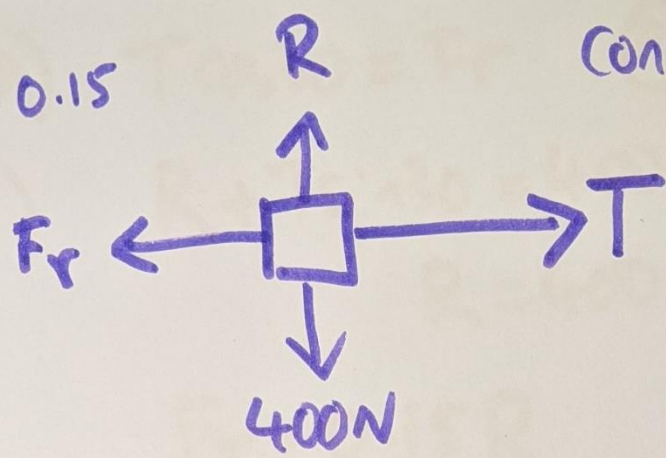
$-9600 = 1200a$

$a = -8$

$0^2 = (10\sqrt{3})^2 + 2(-8)s$ $\quad$ $\underline{s = 18.75m}$

8

$\mu = 0.15$




Constant speed so $a = 0$

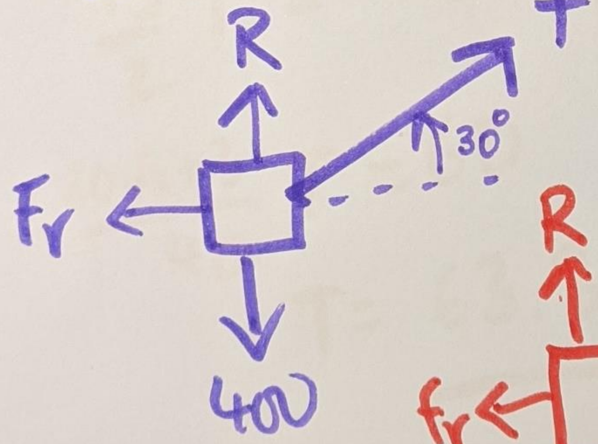
i $F_r = 0.15(400)$
$= 60N$

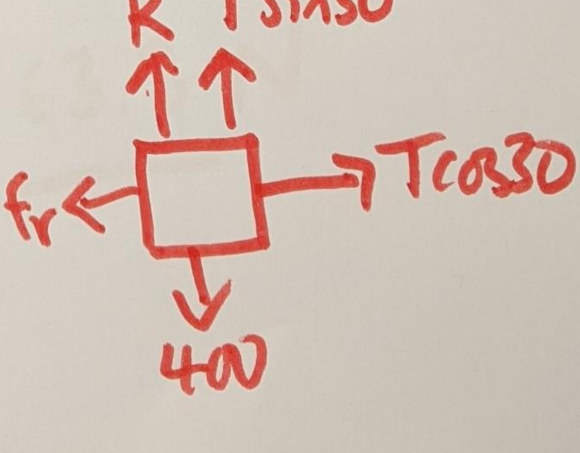
$F = ma$

$T - 60 = 40(0)$

$\underline{T = 60N}$

ii




R is no longer the same as the weight.

$(\rightarrow)$ $T\cos 30 = Fr$ A

$(\uparrow)$ $R + T\sin 30 = 400$

$R = 400 - T\sin 30$

$F_r = 0.15R$

$F_r = 0.15(400 - T\sin 30)$ B

Sub B into A

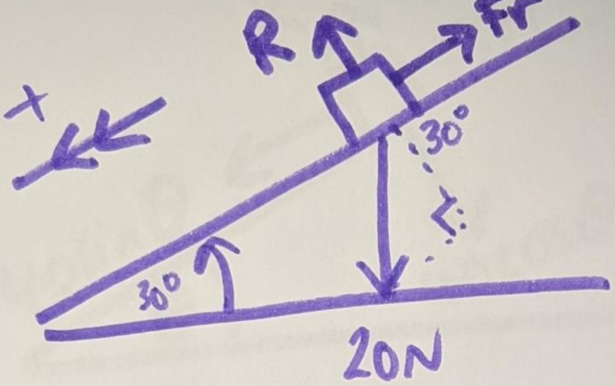
$T\cos 30 = 0.15(400 - T\sin 30)$

$\frac{\sqrt{3}}{2}T = 60 - \frac{3}{40}T$

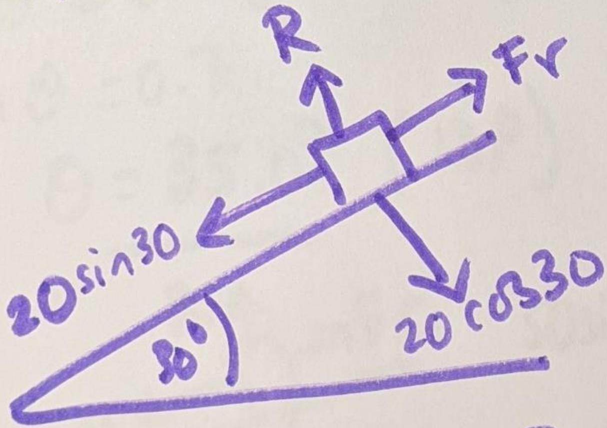
$\frac{20\sqrt{3}+3}{40}T = 60$

$T = \underline{63.8\text{ N}}$

9 i




"Is about to slide" means Friction has reached its maximum and matches the weight component pulling it down the slope.



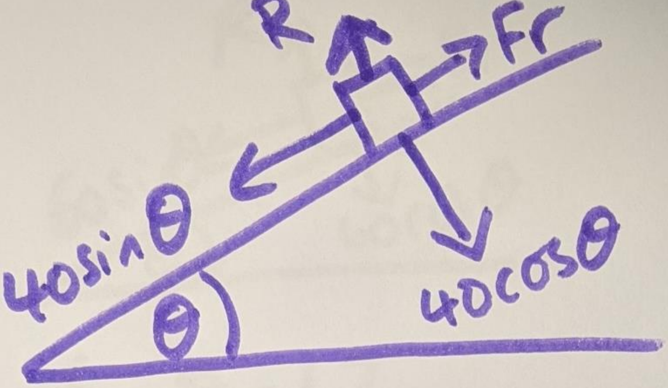

$R = 20\cos 30 = 10\sqrt{3}$

$Fr = \mu R$

$20\sin 30 = \mu(10\sqrt{3})$

$\mu = \frac{1}{\sqrt{3}}$ or $0.577$ (3sf)

9 ii




$R = 40\cos\theta$

$Fr = 40\sin\theta$

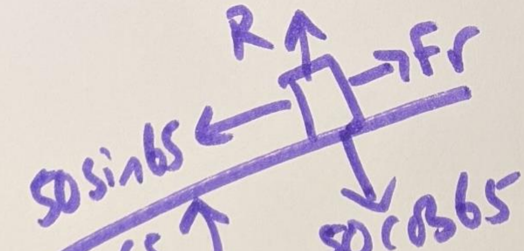
$Fr = 0.7R$

$40\sin\theta = 0.7(40\cos\theta)$

$\tan\theta = 0.7$

$\underline{\theta = 35.0^\circ}$ (1DP)

9 iii



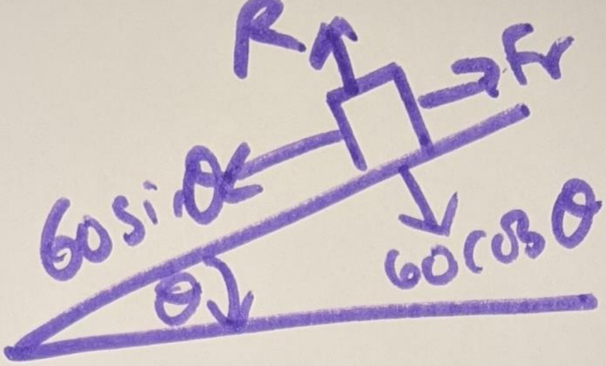

$50\sin65 = \mu\, 50\cos65$

$\mu = \tan65$

$\mu = 2.14$ (3SF)

~~50cos65 = μ 50sin65~~

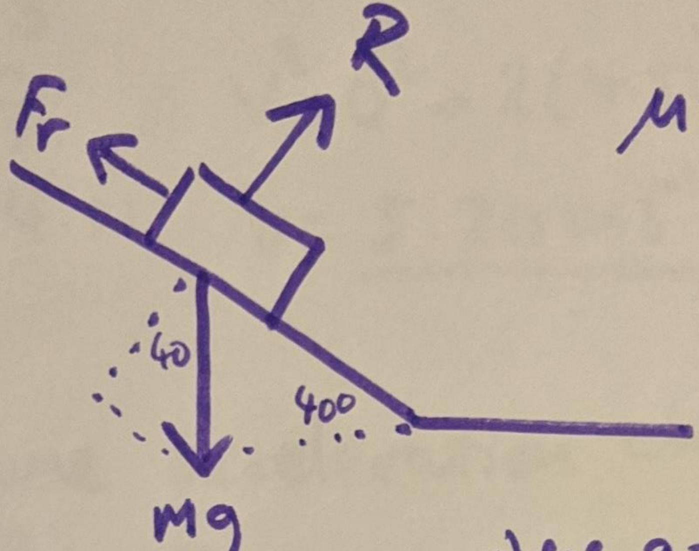
9 iv




$\tan\theta = 1.2$

$\theta = 50.2^\circ$ (1DP)

10

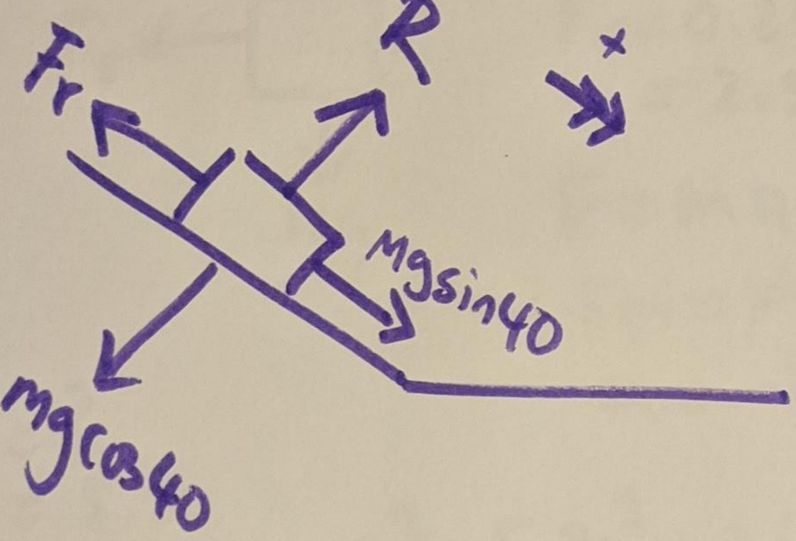



$\mu = 0.25$

Don't know mass so call it m.

where $g = 10ms^{-2}$

(i)




(ii) $Fr = 0.25R$

$= 0.25 mg\cos 40$

$F = ma$

$\cancel{m}g\sin 40 - 0.25\cancel{m}g\cos 40 = \cancel{m}a$

$a = 10\sin 40 - 0.25(10\cos 40) = 4.51\ ms^{-2}$

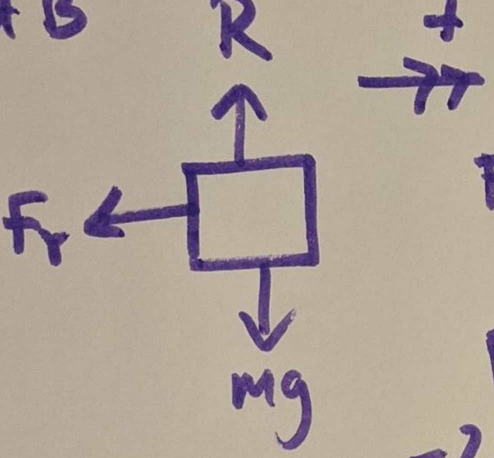
(iii)

$s = 3$
$u = 0$
$v = ?$
$a = 4.51$
$t$

$v^2 = 0^2 + 2(4.51)(3)$

$v = \underline{5.20\,ms^{-1}}$ (3SF)

(iv) Assume acceleration changes at B




$Fr = 0.25(mg)$
$= 2.5m$

$F = ma$

$-2.5\cancel{m} = \cancel{m}a$

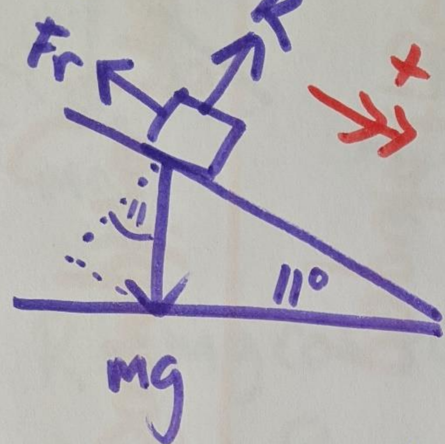
$a = -2.5$

$s = ?$
$u = 5.20$
$v = 0$
$a = -2.5$
$t$

$0^2 = 5.20^2 + 2(-2.5)s$

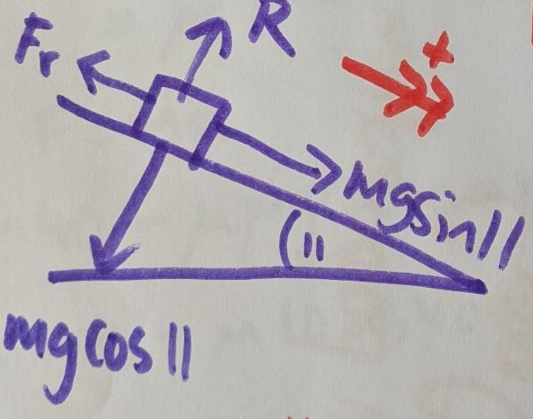
$s = \underline{5.42\,m}$ (3SF)

(11) (i) Use the 11° section to find the coefficient of friction.




$g = 10\ ms^{-2}$
The acceleration due to gravity.

Break it down!




$R = mg\cos 11°$

$F_r = \mu R$
and $a = 0$
because
speed is
constant.

$F_r = \mu mg\cos 11$

$F = ma$

$\cancel{m}g\sin 11 - \mu \cancel{m}g\cos 11 = \cancel{m}(0)$

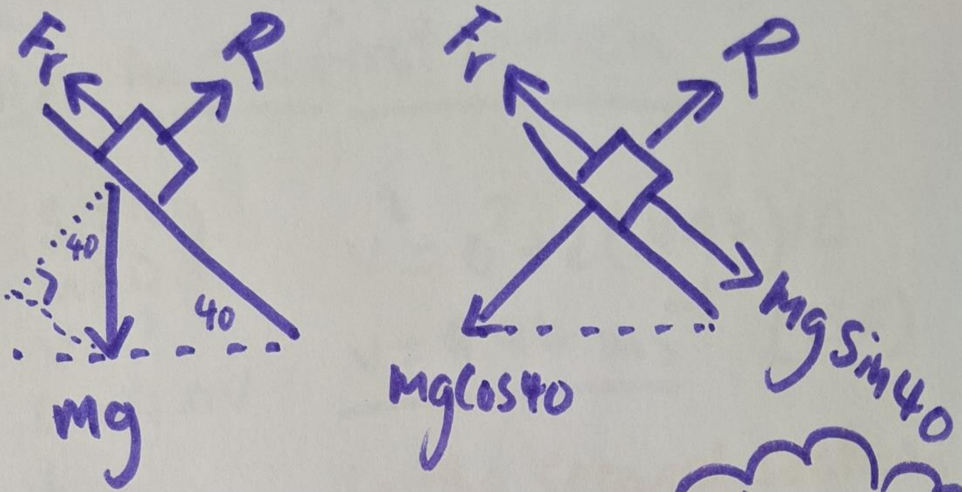
$10\sin 11 = \mu\, 10\cos 11$

$\tan 11 = \mu$

50

$\mu = 0.194$

11 (ii)




where $g = 10ms^{-2}$

$R = mg\cos 40$

$Fr = \mu R$

$= \mu mg\cos 40$

$F = ma$

$\cancel{m}g\sin 40 - \mu \cancel{m}g\cos 40 = \cancel{m}a$

$10\sin 40 - \mu 10\cos 40 = a$

$\mu = 0.194$ from part (i)

$a = \underline{4.94\ ms^{-2}}$ (3SF)

(ii) (iii) In the first section

$s = 10$
$u = 0$
$v = ?$
$a = 4.94$
$t$

$v^2 = 0^2 + 2(4.94)10$

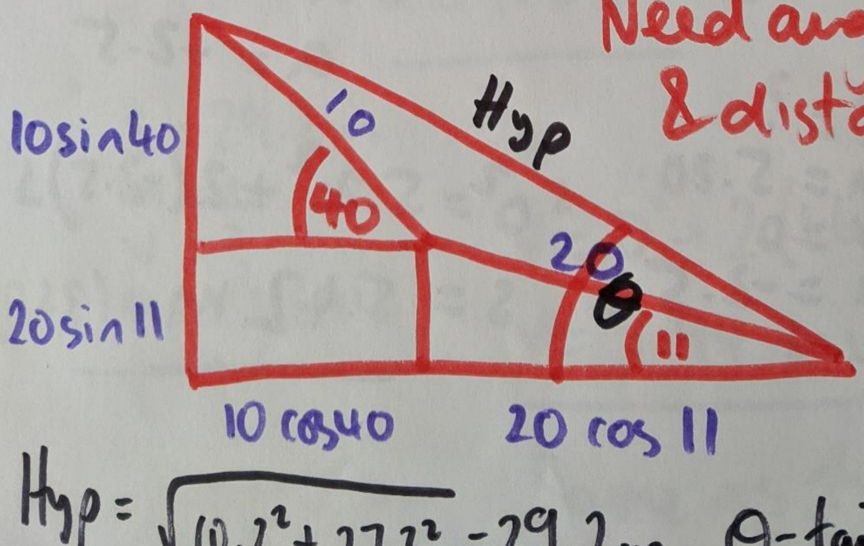
$v = 9.94\ ms^{-1}$ (3SF)

In the second section they stay at a constant speed so the finish with speed of 9.94 $ms^{-1}$

---

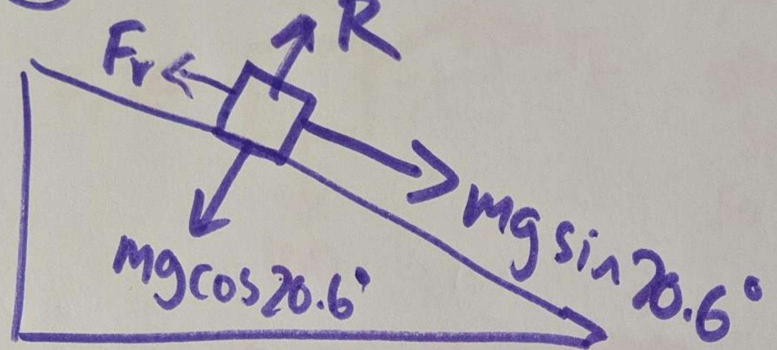
(iv) This question is complicated!

Need angle & distance!




$Hyp = \sqrt{10.2^2 + 27.3^2} = 29.2m$ $\quad \theta = \tan^{-1}\left(\frac{10.2}{27.3}\right) = 20.6^\circ$

11 iv continued.




$R = mg\cos 20.6$

$F_r = 0.194R$

$F = ma$

$mg\sin 20.6 - 0.194(mg\cos 20.6) = ma$

$\underline{a = 1.694\ ms^{-2}}$

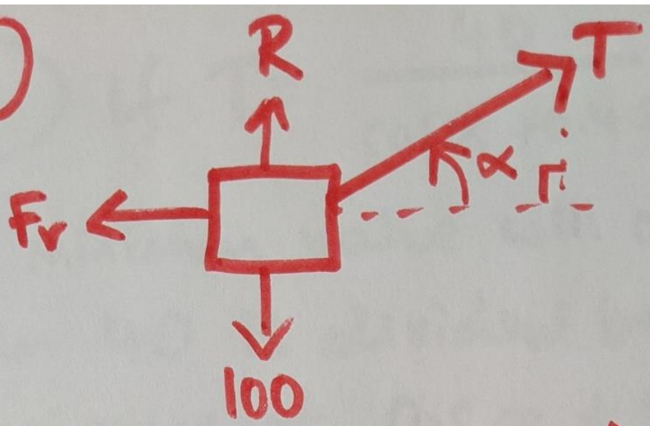
$s = 29.2\,m$
$u = 0$
$v = ?$
$a = 1.694$
$t$

$v^2 = 0^2 + 2(1.694)29.2$

$\underline{v = 9.94\ ms^{-1}}$

Same as the other slide!

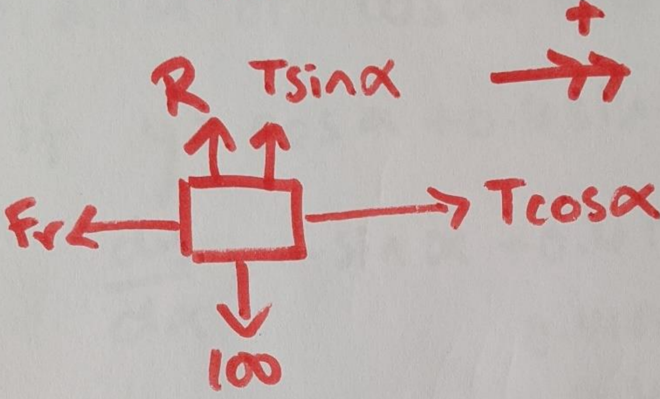
12 i




$\mu = 0.4$

steady speed

so $a = 0$




$$R = 100 - T\sin\alpha$$

$$Fr = 0.4(100 - T\sin\alpha)$$

$$T\cos\alpha - 0.4(100 - T\sin\alpha) = 0$$

$$T\cos\alpha = 40 - 0.4T\sin\alpha$$

$$T(\cos\alpha + 0.4\sin\alpha) = 40$$

$$T = \frac{40}{\cos\alpha + 0.4\sin\alpha}$$

a) $\alpha = 10, T = 37.9N$

b) $\alpha = 20, T = 37.2N$

c) $\alpha = 30, T = 37.5N$

$\boxed{\text{part ii}}$

12iii If $T = \dfrac{40}{\cos\alpha + 0.4\sin\alpha}$

The minimum value will occur when 40 is divided be the maximum of $\cos\alpha + 0.4\sin\alpha$

so if $y = \cos\alpha + 0.4\sin\alpha$

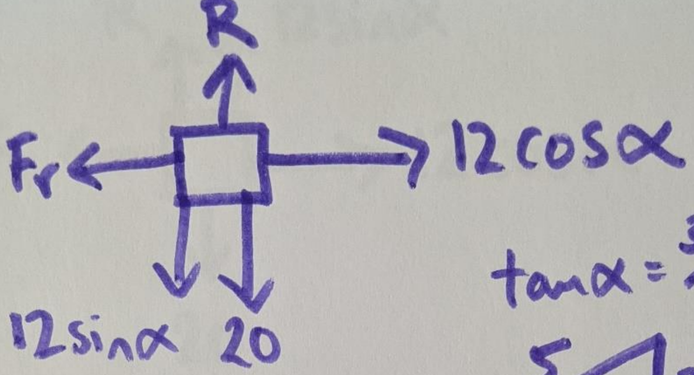
$$\frac{dy}{d\alpha} = -\sin\alpha + 0.4\cos\alpha = 0$$

$$0.4\cos\alpha = \sin\alpha$$

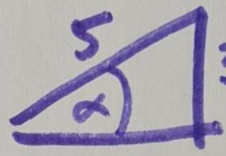
$$0.4 = \tan\alpha$$

$$\alpha = 21.8^\circ$$

13 i




tan α = 3/4




$\sin\alpha = \frac{3}{5}$

$\cos\alpha = \frac{4}{5}$

$F_r = \mu R$

$F_r = \mu\left(12\left(\frac{3}{5}\right) + 20\right)$

$F_r = 27.2\mu$

Frictional force $\geq 12\cos\alpha$

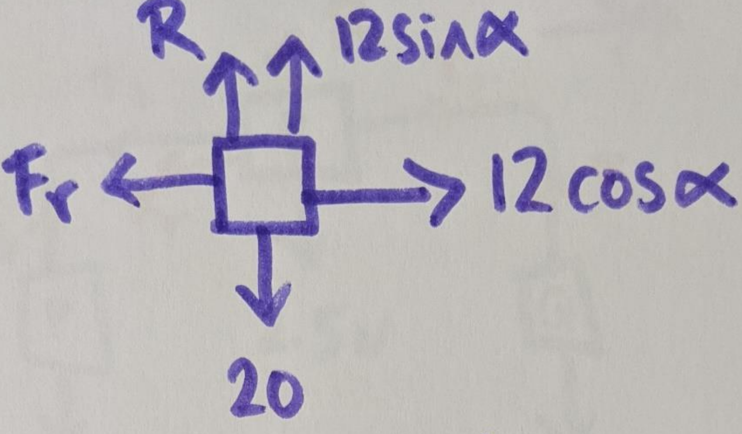
because it hasn't moved yet.

$27.2\mu \geq 12\left(\frac{4}{5}\right)$

$\mu \geq \frac{48}{5} \div \frac{136}{5}$

$\mu \geq \frac{6}{17}$ as required.

13 ii




$$F_r = \mu(20 - 7.2)$$

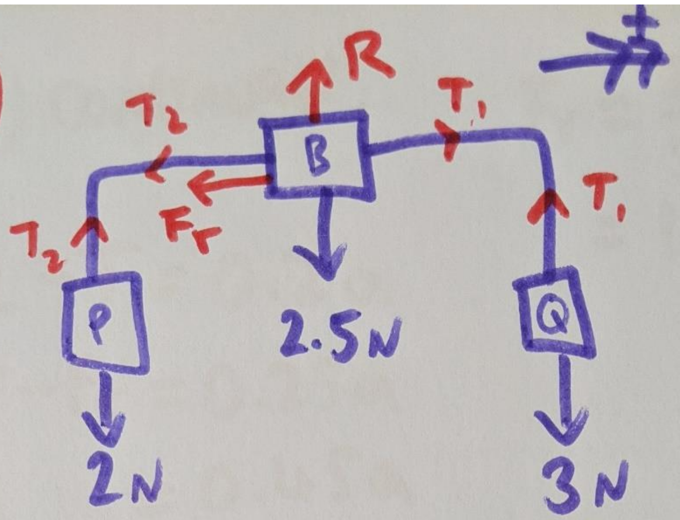
$$F_r = 12.8\mu$$

$$12\cos\alpha > F_r$$ because it moves!

$$9.6 > 12.8\mu$$

$$\tfrac{3}{4} > \mu$$

14 i




Not moving so $T_1 = 3$

$T_2 = 2$

$F_r = \mu R$

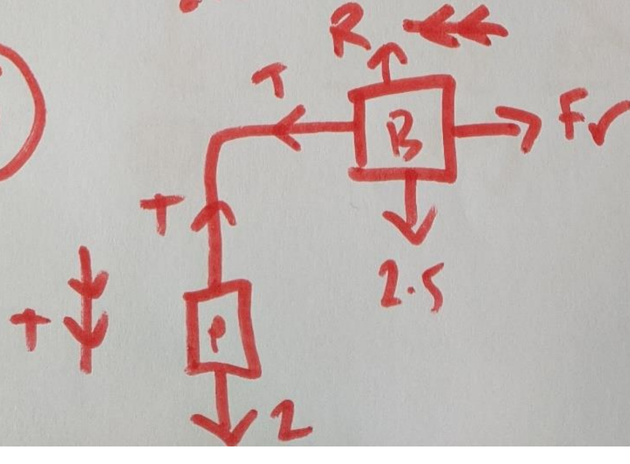
$F_r = \mu(2.5)$

$T_1 = T_2 + F_r$

$3 = 2 + 2.5\mu$

$\mu = \frac{1}{2.5} = 2/5$

ii

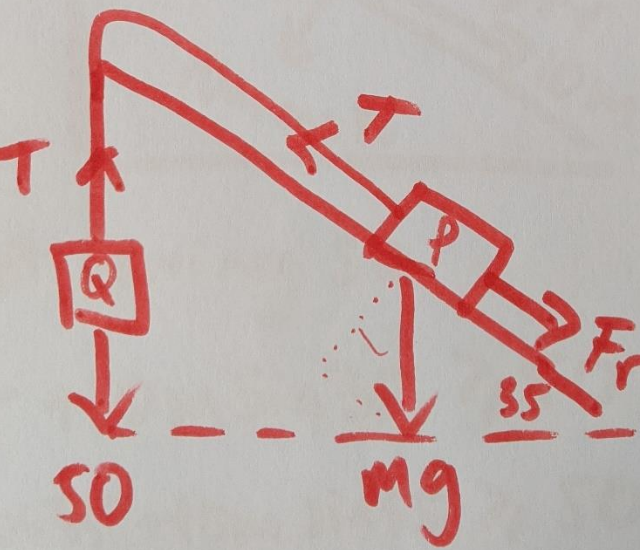


14 ii continued.

$Fr = \frac{2}{5}(2.5)$
$= 1$

$2 - T = 0.2a$
$T - f_r = 0.25a$
$1 = 0.45a$
$a = \underline{2.22}\ ms^{-2}$ (3SF)
$T = \underline{1.56\ N}$ (3SF)

15

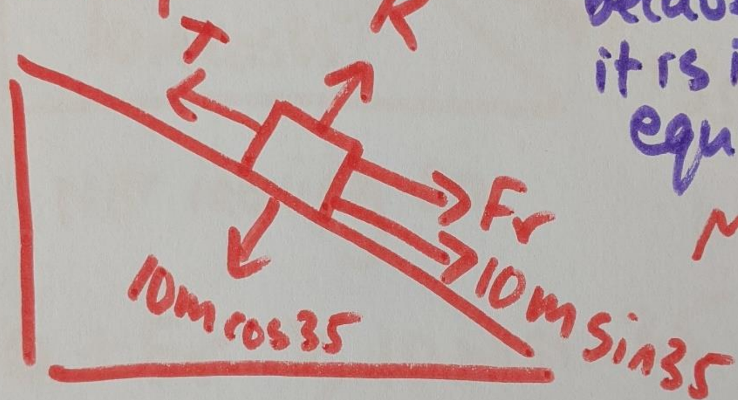



$\mu = 0.2$

$\boxed{\text{15 continued}}$

Friction could be going up or down the slope depending on the size of m

If P is about to slide up the slope.




T=50 because it is in equilibrium

$\mu = 0.2$

Not moving so

$Fr + 10m\sin 35 \geq 50$

$2m\cos 35 + 10m\sin 35 \geq 50$

$m \geq \dfrac{50}{2\cos 35 + 10\sin 35}$

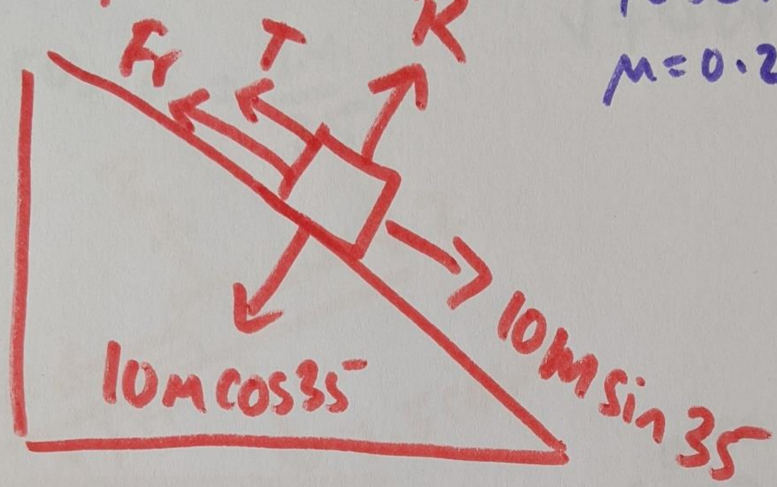
$m \geq 6.78\,kg$

15 still

If P is about to slide down the slope:

$T = 50\,N$

$\mu = 0.2$




NOT moving so

$$50 + Fr \geq 10m\sin 35$$

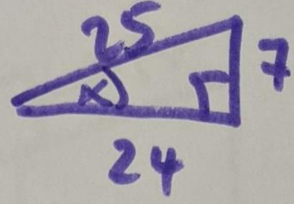
$$50 + 2m\cos 35 \geq 10m\sin 35$$

$$50 \geq m(10\sin 35 - 2\cos 35)$$

$$12.2 \geq m$$

So overall $6.78 \leq m \leq 12.2$

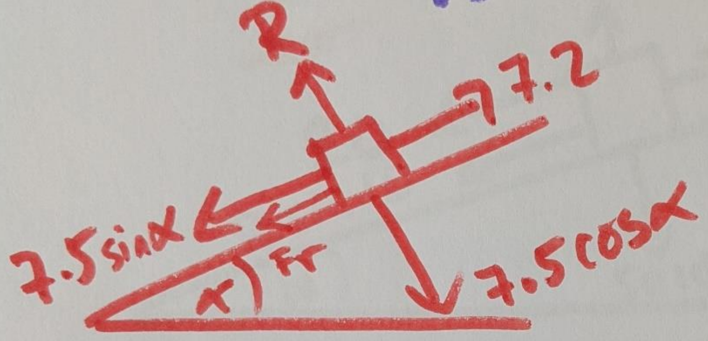
(1b) (i) $\tan\alpha = \frac{7}{24}$




$\sin\alpha = \frac{7}{25}$

$\sqrt{7^2+24^2} = 25$

$\cos\alpha = \frac{24}{25}$




because 7.2 is not enough to overcome friction

$Fr = \mu(7.2)$

$7.5\left(\frac{7}{25}\right) + 7.2\mu \geqslant 7.2$

$7.2\mu \geqslant 5.1$

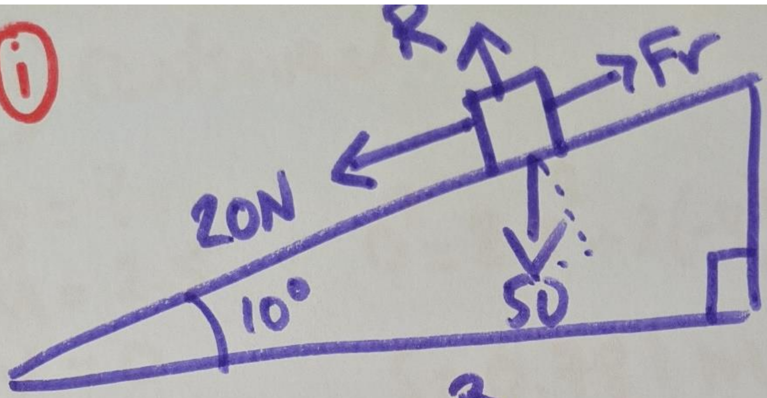
$\mu \geqslant \frac{17}{24}$

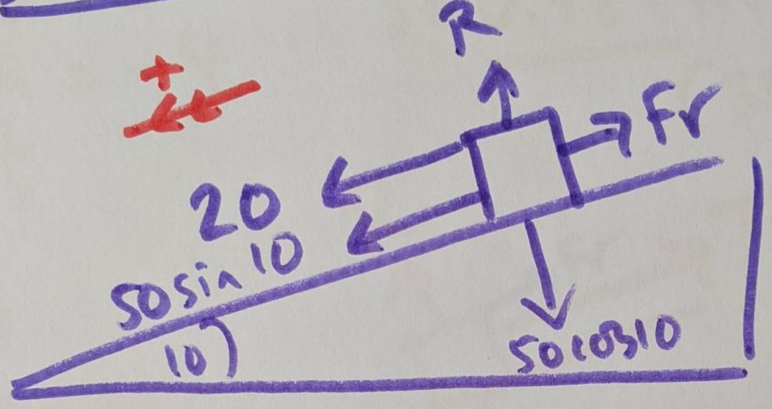
(ii) $7.5\left(\frac{7}{25}\right) + 7.2 > Fr$

$9.3 > \mu(7.2)$

$\mu < \frac{31}{24}$

17 i




$Fr = \mu(50\cos 10)$

constant speed so

$20 + 50\sin 10 = \mu(50\cos 10)$

$\mu = \underline{0.582}$ (3SF)

ii $50\sin 10 - Fr = 5a$

$\dfrac{50\sin 10 - 0.582(50\cos 10)}{5} = a$

$a = -4\ ms^{-2}$

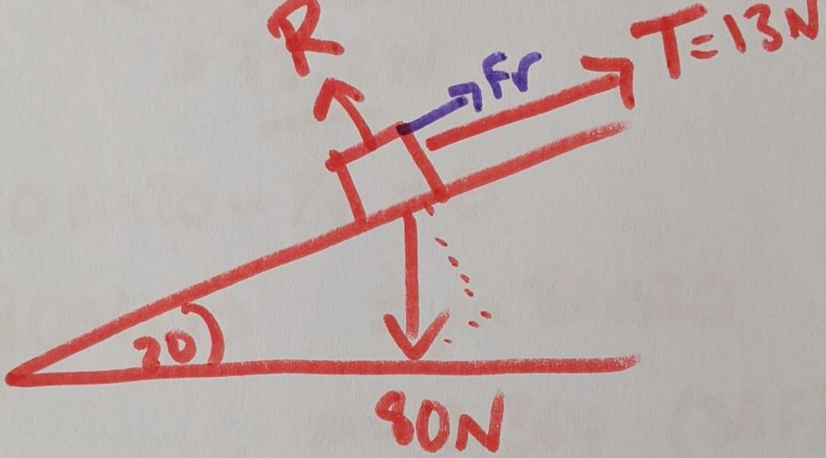
17 ii continued.

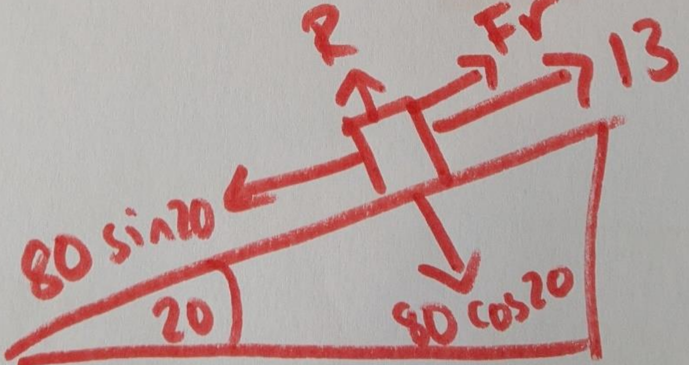
$s = ?$
$u = 2.5$
$v = 0$
$a = -4$
$t$

$0^2 = 2.5^2 + 2(-4)s$

$s = \underline{0.781\ m}$ (3SF)

18




Friction going up the slope since $80\sin 20 > 13$

(18) continued

In balance so:

$Fr + 13 = 80\sin 20$

$Fr = \underline{14.4N}$

$R = 80\cos 20$

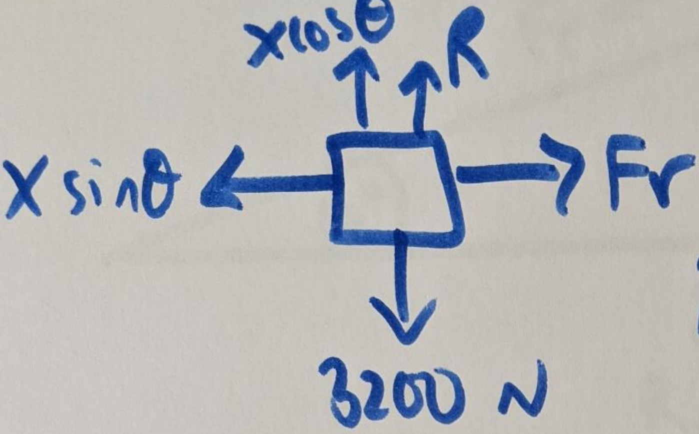
$= \underline{75.2N}$

(ii) $80\sin 20 - Fr = 0$

$80\sin 20 = \mu\, 80\cos 20$

$\mu = \underline{0.364}$ (3SF)

(19) (i) $\tan\theta = \frac{7}{24}$ $\sin\theta = \frac{7}{25}$ $\cos\theta = \frac{24}{25}$




$R = 3200 - \frac{24}{25}X$

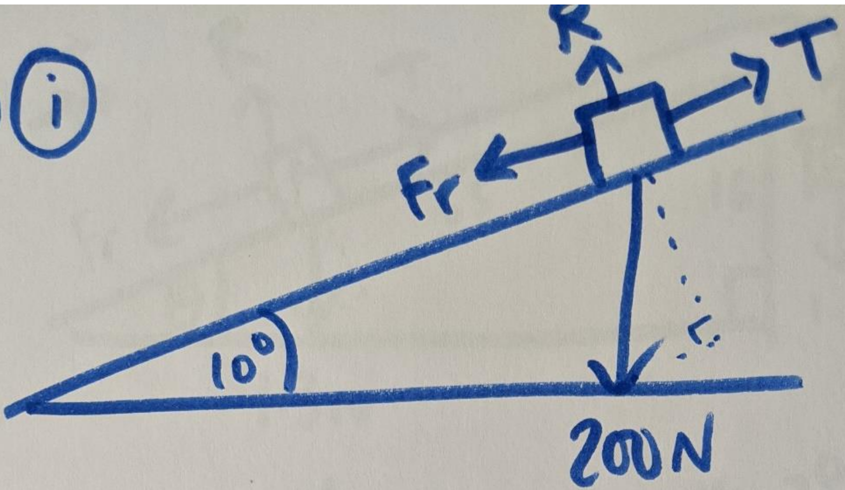
(ii) $X\sin\theta = \frac{3}{8}\left(3200 - \frac{24}{25}X\right)$

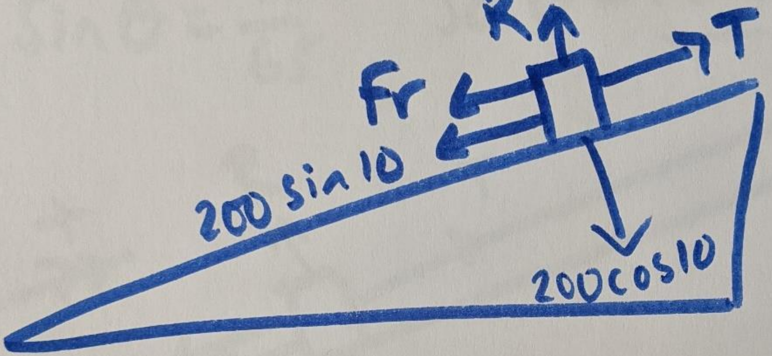
$\frac{7}{25}X = 1200 - \frac{9}{25}X$

$\frac{16}{25}x = 1200$

$x = \underline{1875\text{ N}}$

20 (i)




To get things moving ..... ie $a=0$

$$T = F_r + 200\sin 10$$

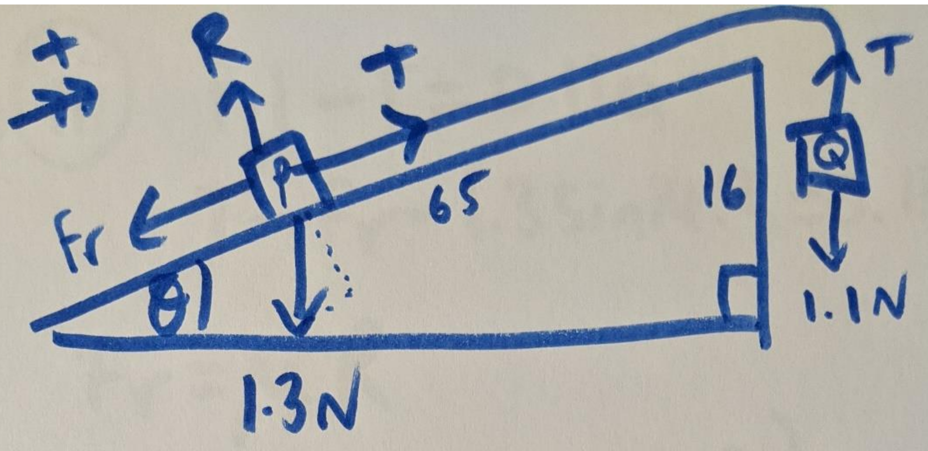
$$= 0.32(200\cos 10) + 200\sin 10$$

$$= \underline{97.8\ N}$$

(ii) Friction flips over and

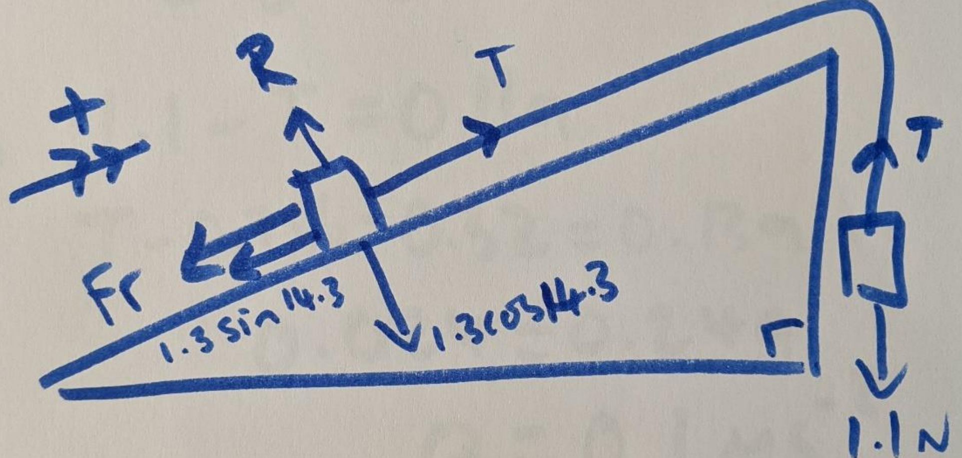
$$T = f_r - 200\sin 10 = 28.3\,N$$

(21)




$\sin\theta = \frac{16}{65}$ so $\theta = \underline{14.3^\circ}$

(i)




(ii) $T > F_r + 1.3 \sin 14.3$

$T - F_r > 0.32$ as required.

(iii) ~~$1.1 - T = 0.11a$~~

~~$T - 0.6(1.3\cos 14.3) = 0.13a$~~

~~$0.344 = 0.24a$~~ ~~$a = 1.43 ms^{-2}$~~

21 iii $1.1 - T = 0.11a$

$T - Fr - 1.3\sin 14.3 = 0.13a$

$Fr = \mu R$

$= 0.6(1.3\cos 14.3)$

$= 0.756$

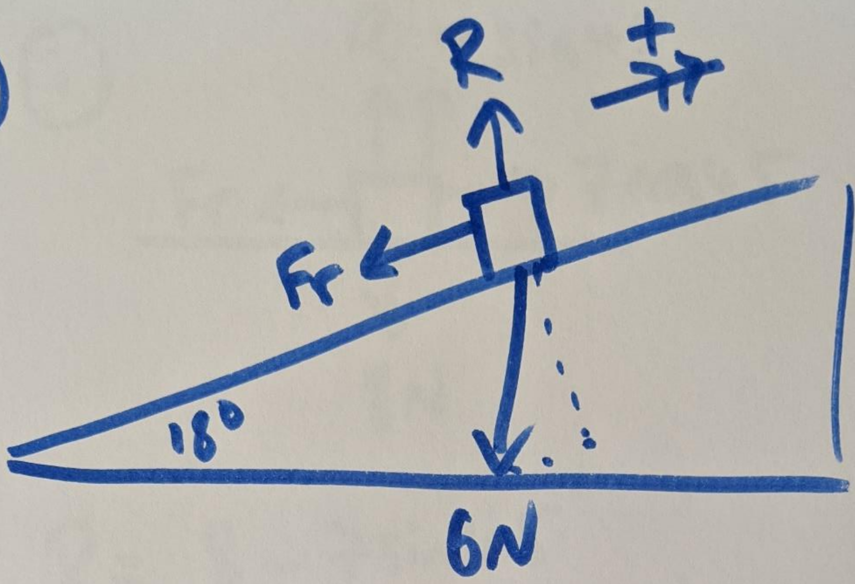
So $1.1 - T = 0.11a$

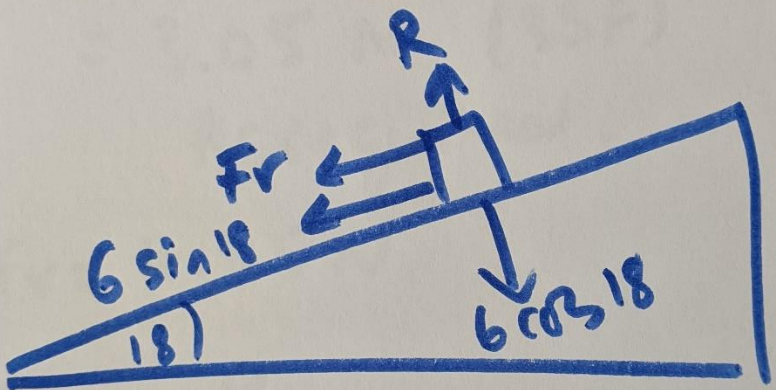
$T - 0.756 - 0.32 = 0.13a$

$0.024 = 0.24a$

$a = \underline{0.1\,ms^{-2}}$

22



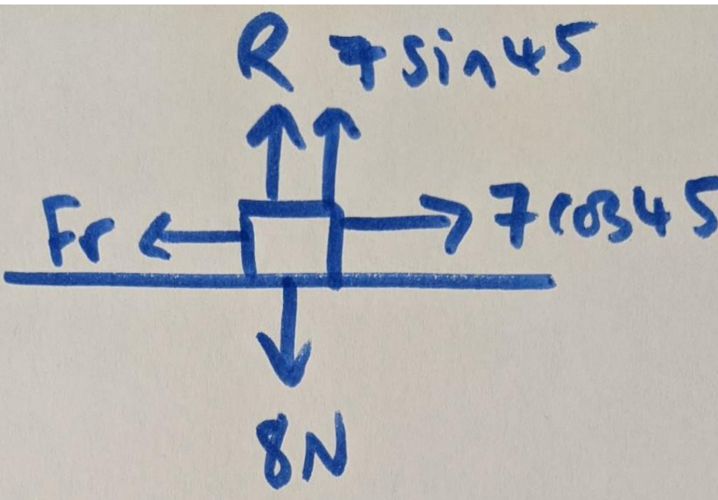

$-Fr - 6\sin 18 = 0.6(4)$

$Fr = \underline{0.546}\ N$ 3SF

$R = 6\cos 18$
$= 5.71\ N$ (3SF)

$Fr = \mu R$
so $\mu = 0.0957$ (3sf)

23 (i)




$R = 8 - 7\sin 45$

$= 3.05\ \text{N}$ (3SF)

As required.

(ii) $Fr = 4.95\ \text{N}$

$Fr = \mu R$

$\mu = \underline{1.62}$ (3SF)