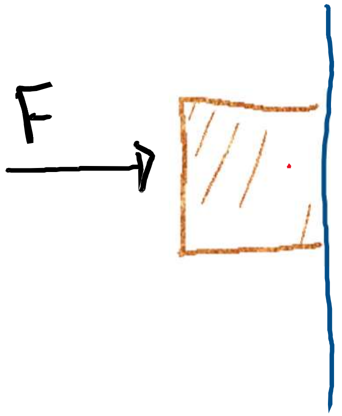
Solved Examples

What is the least amount of force you must exert on the block to keep it in place. The block has a mass of 2.2 kg and the coefficient of static friction between the wall and block is 0.65



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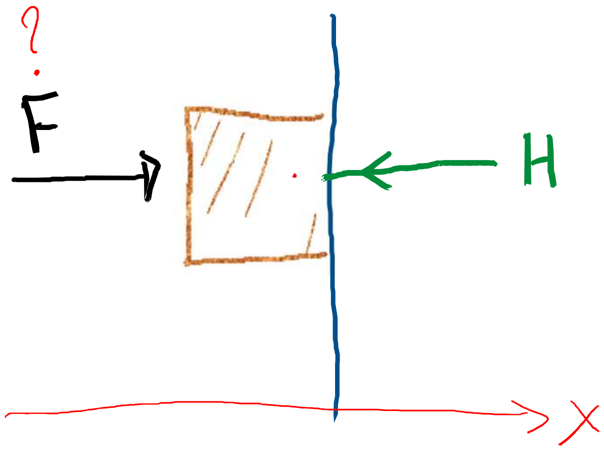

$$\sum F_x = 0$$

$$F + (-H) = 0$$

$$F = H$$

$$\sum F_{\rightarrow} = \sum F_{\leftarrow}$$

$$F = H$$

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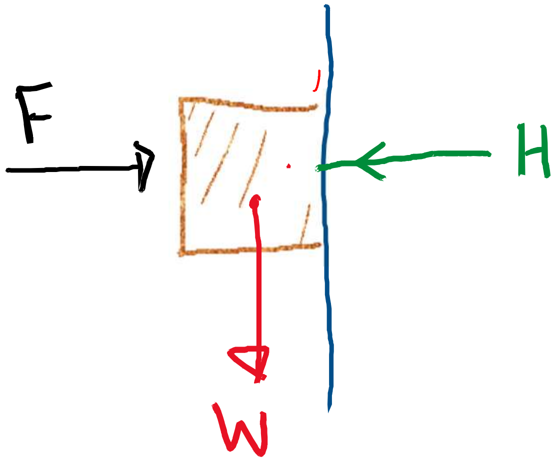

$$\Sigma F_x = 0$$

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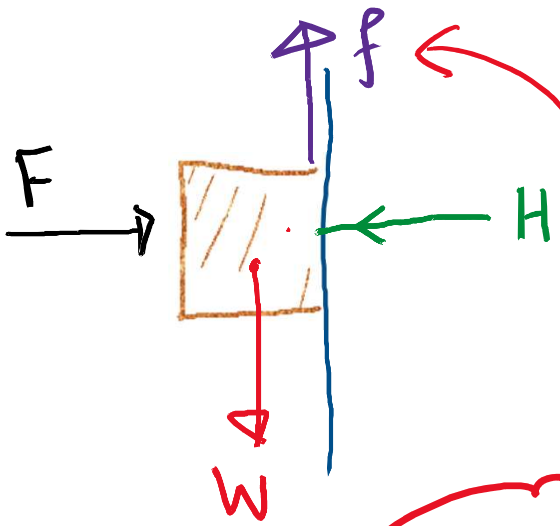

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Since it is not sliding down, friction ensures that

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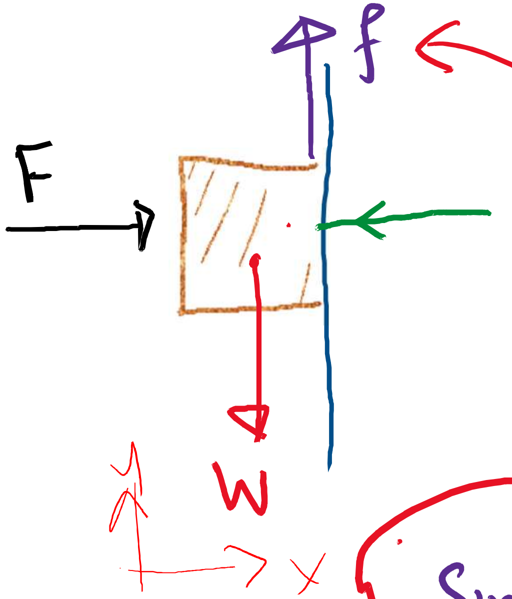


$\Sigma F_x = 0$

$F + (-H) = 0$

$F = H$

$\Sigma F_y = 0$

$f + (-W) = 0$

$f = W = 2.2 \times 9.8$

But $f = \mu_s F_N = 21.56N$

$\therefore F_N = \dfrac{21.56}{0.65} = 33.2N$

Since it is not sliding down. Friction ensures that

Application of N - 2nd Law.

Here is a general procedure of solving problems relating to N - 2nd Law.

☑ 1. Sketch a picture of the problem

☑ 2. Isolate the object for which you wish to write $F = ma$

☑ 3. Draw a FBD for the isolated body showing all the forces acting on it. Do not include forces that do not act directly.

☑ 4. Choose a convinient coordinate system and find the components of the forces. → $\Sigma F_x = ma_x$, $\Sigma F_y = m$

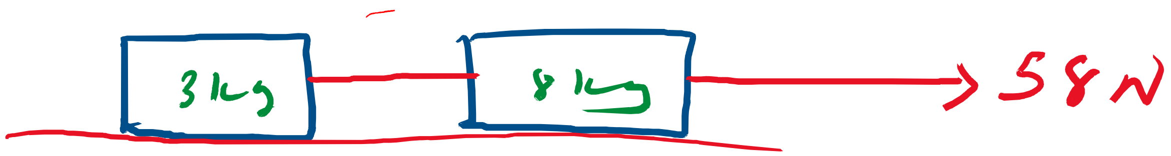
☑ 5. Write $F = ma$ eqns in component form for the forces in the FBD. Remember to use SI unit

☑ 6. Solve the component eqns for the unknowns

☑ 7. Check the reasonableness of your results.

Ex: The tension in the rope pulling the 2 blocks is 58N. Find the acceleration of the blocks and the tension in the cord connecting the blocks. Friction is negligible.

(smooth)



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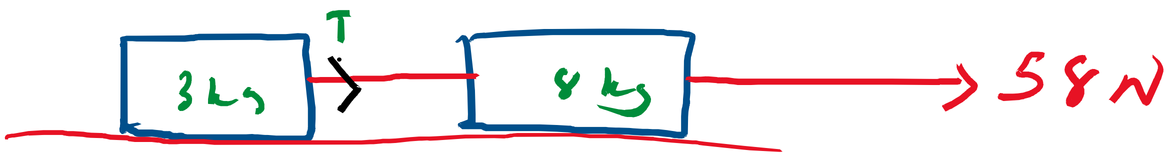
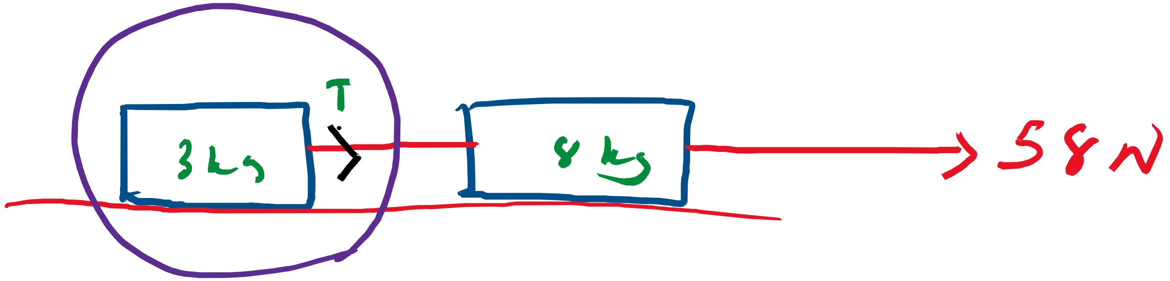


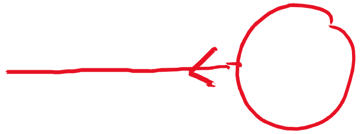
$\Sigma F = ma$; $58 = (3+8)a$

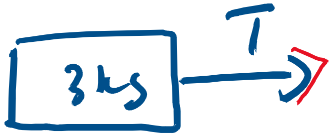
58

$a = 5.27 \, m/s^2$

Ex: The tension in the rope pulling the 2 blocks is 58N. Find the acceleration of the blocks and the tension in the cord connecting the blocks. Friction is negligible.







$$\Sigma F = ma \; ; \quad 58 = (3+8)a$$

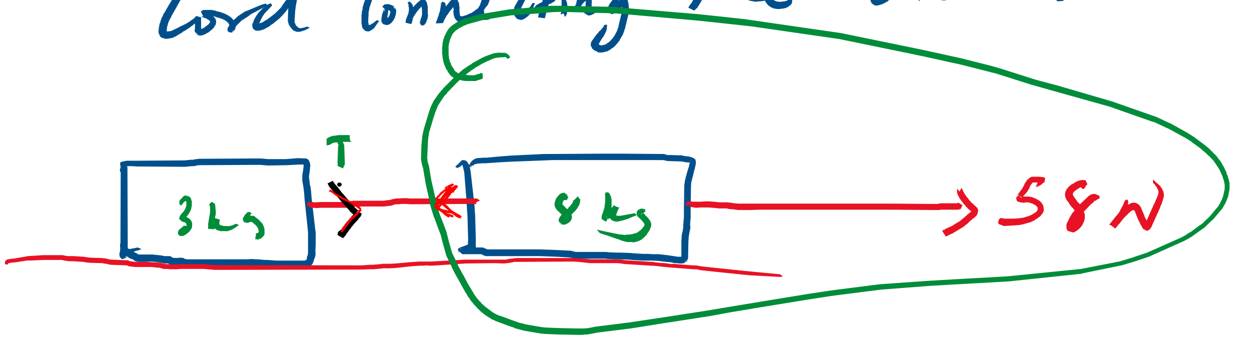
$$a = 5.27 \, m/s^2$$

58

$$\Sigma F = ma$$

$$T = 3(5.27) = \underline{15.8 N}$$

Ex: The tension in the rope pulling the 2 blocks is 58N. Find the acceleration of the blocks and the tension in the cord connecting the blocks. Friction is negligible.



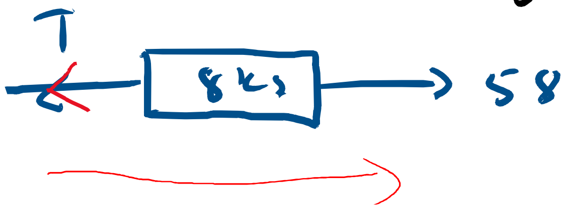
Tension is always away from the object

$\Sigma F = ma$; $58 = (3+8)a$

$a = 5.27\ m/s^2$

58

OR



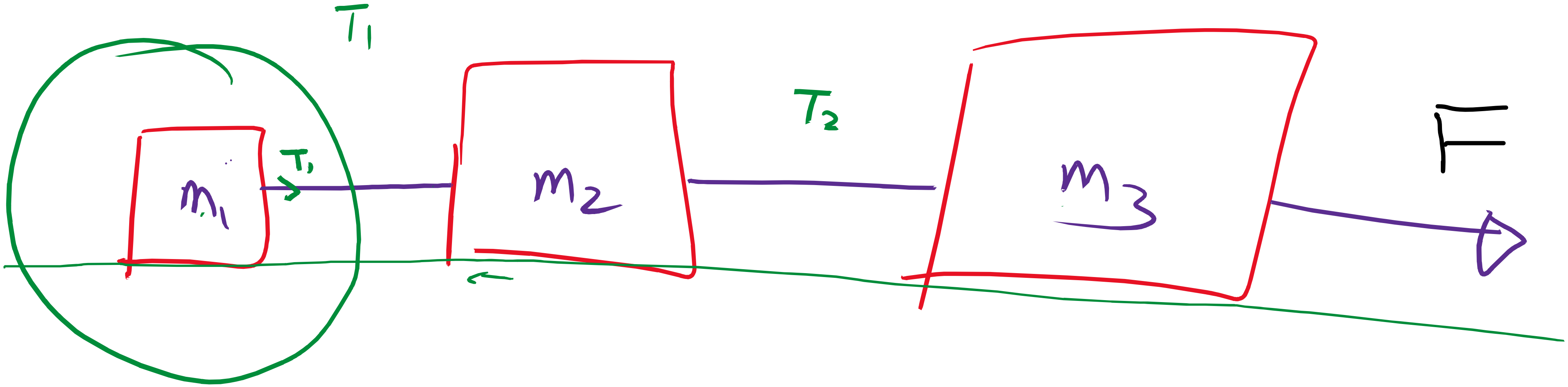
$\Sigma F = ma$

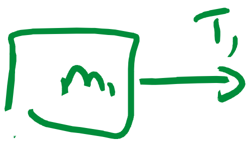
$58 + (-T) = 8(5.27)$

$F_n = ma$

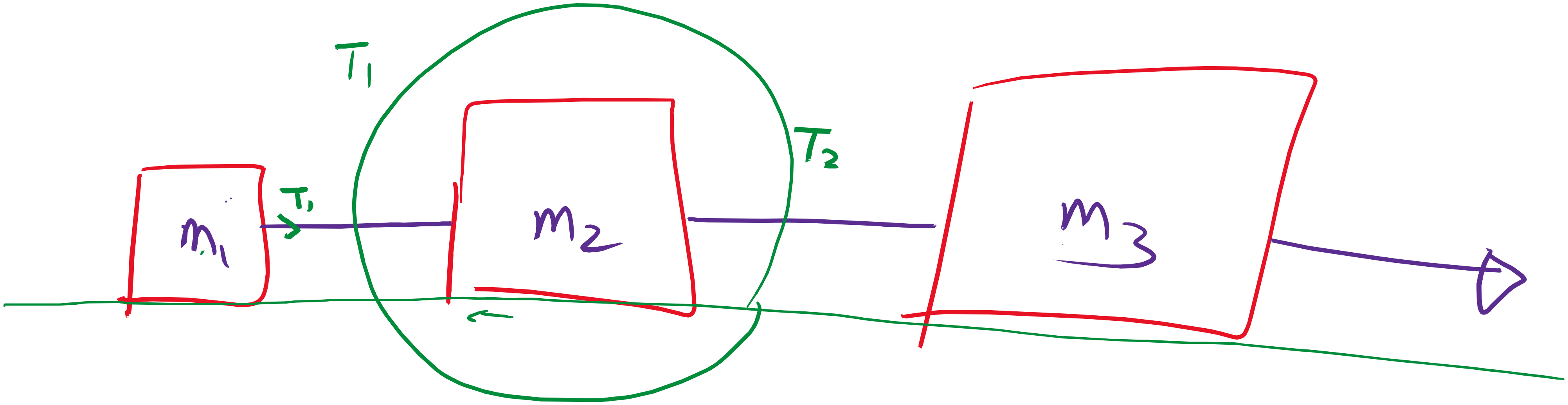
$58 - T = 8(5.27)$

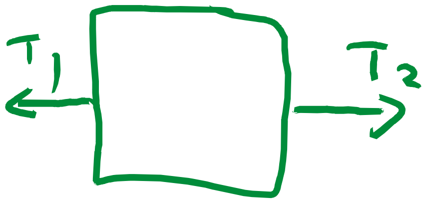
$T = 15.8\ N$



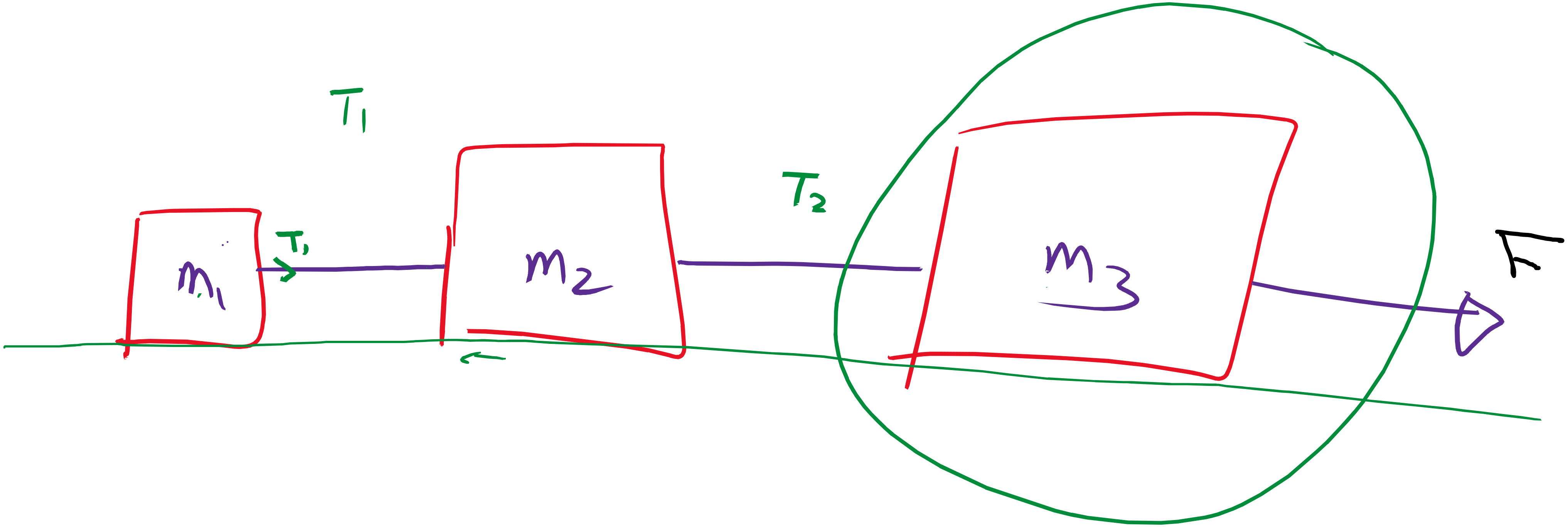


$$T_1 = m_1 a$$



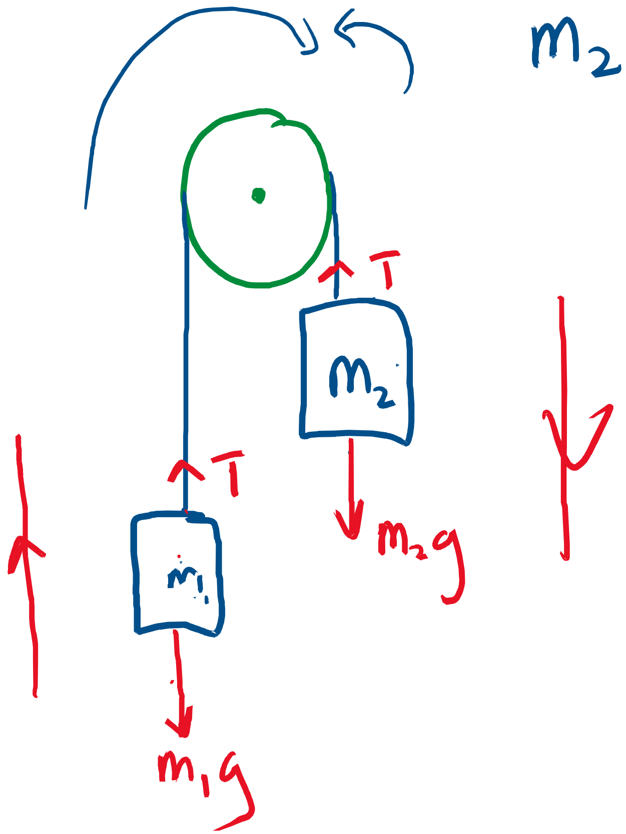


$$T_2 + (-T_1) = m_2 a$$



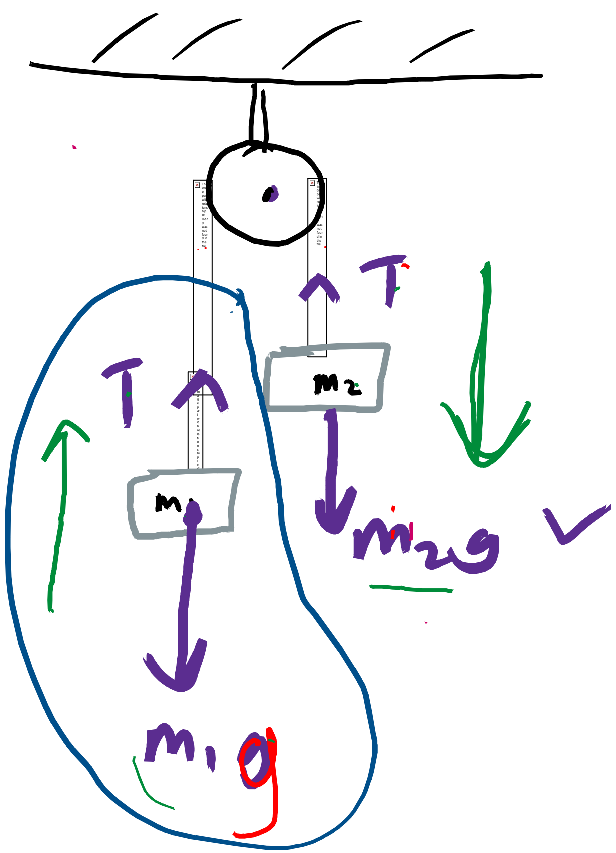
$$F + (-T_2) = m_3 a$$

$m_2 > m_1$



Atwood Machine

$2 \quad T = ma$



$m_1 = 5.0\,kg$

$m_2 = 10.0\,kg$

Find the acceleration of the masses.

$$T - m_1 g = m_1 a \quad (1)$$

$$+$$

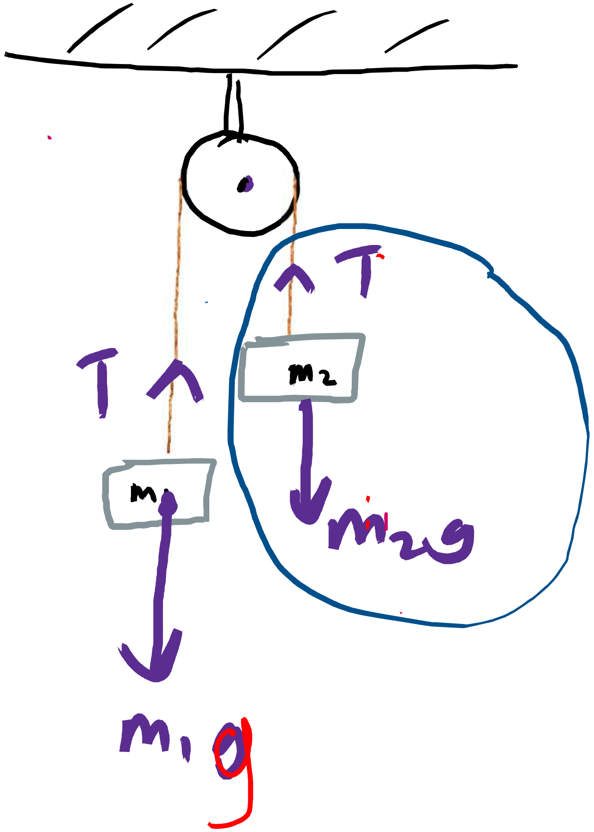
$$m_2 g - T = m_2 a \quad (2)$$

$$m_2 g - m_1 g = (m_1 + m_2) a$$

$$(m_2 - m_1) g = (m_1 + m_2) a$$

Atwood Machine

$T = m$



$m_1 = 5.0\,kg$

$m_2 = 10.0\,kg$

Find the acceleration of the masses.

$$T - m_1 g = m_1 a \quad (1)$$

$$m_2 g - \cancel{T} = m_2 a \quad (2)$$

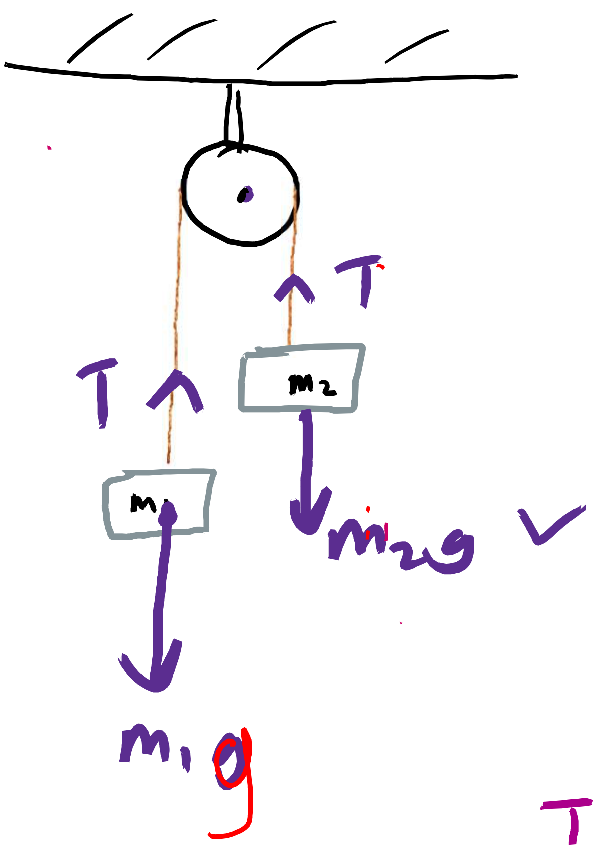
$$m_2 g - m_1 g = (m_1 + m_2) a$$

$$(m_2 - m_1) g = (m_1 + m_2) a$$

$$a = \left[\frac{m_2 - m_1}{m_1 + m_2}\right] g$$

Atwood Machine

$T = m a$



$m_1 = 5.0\,kg$

$m_2 = 10.0\,kg$

Find the acceleration of the masses.

?

$$a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g = \left(\frac{10-5}{15}\right) 9.8$$

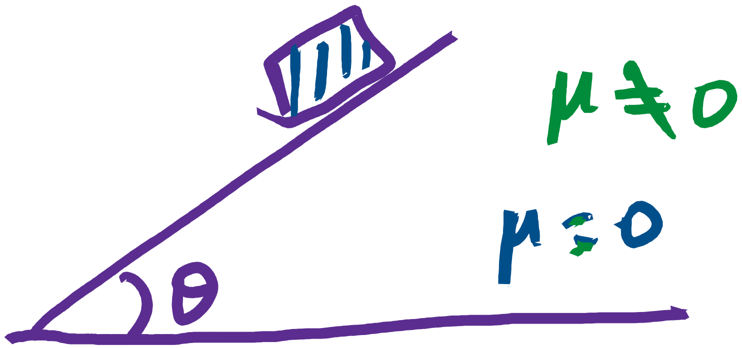
$$a = 3.27\,m/s^2$$

$$T - m_1 g = m_1 a$$

$$T = m_1 a + m_1 g = m_1 [a + g] = 5(3.27 + 9.8)$$

Motion on an Incline

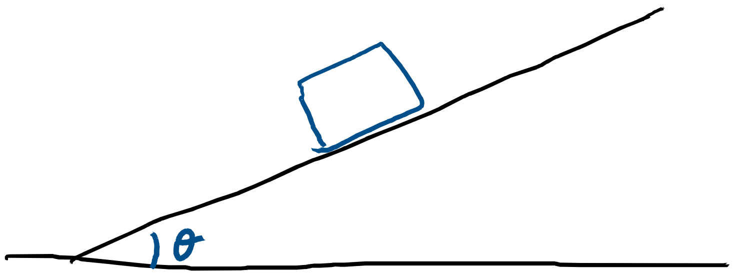
- This is the motion on a surface that is slanted.



- Without pushing the object, the object still slides down the Incline
- What is the cause?
  Force/energy.

$\Rightarrow$ - What is this force?

Consider an object on the incline. Assume the surface is smooth.



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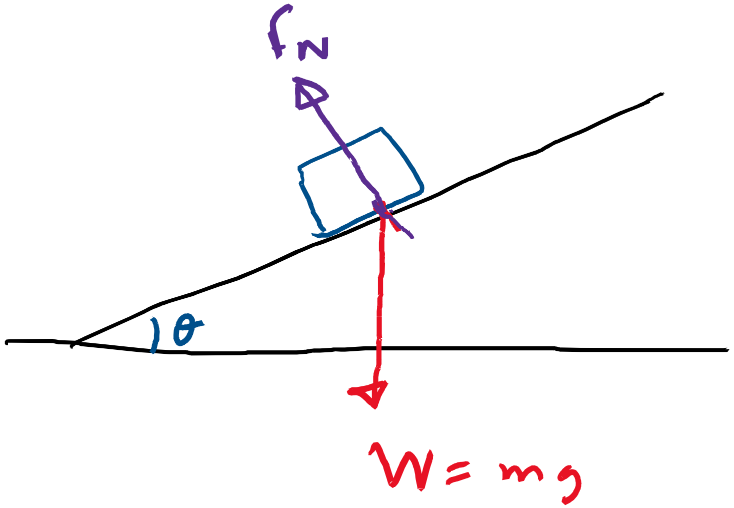
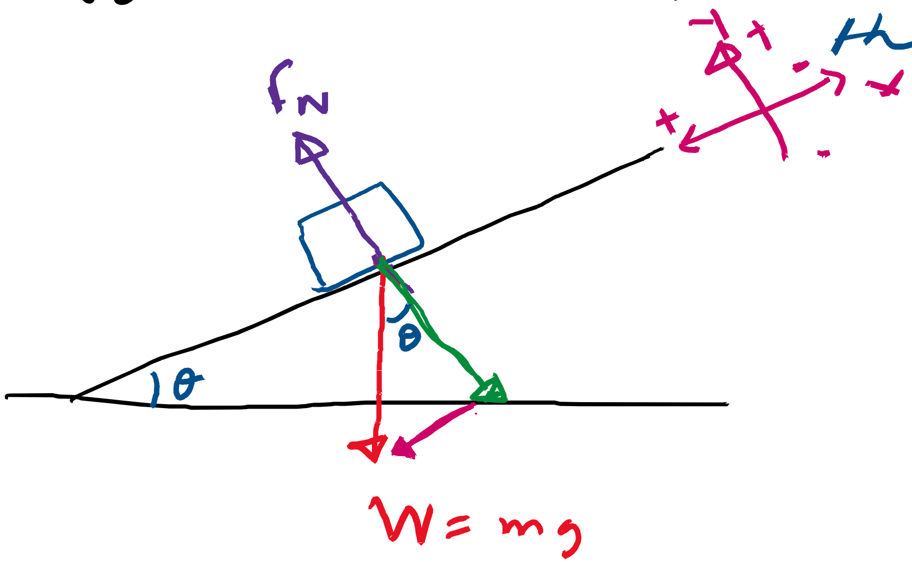


Normal force

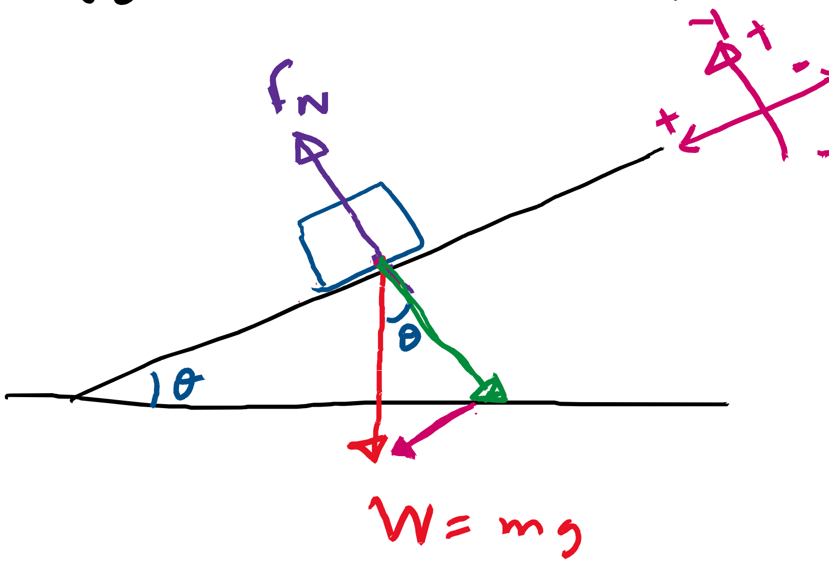
Weight

Consider an object on the incline. Assume the surface is smooth.



Resolve the weight into components

Consider an object on the incline. Assume the surface is smooth.



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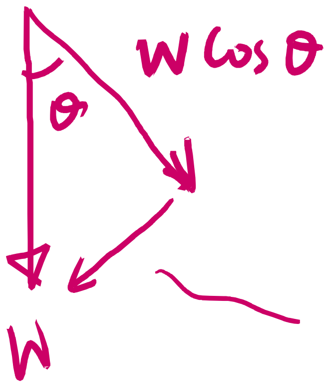
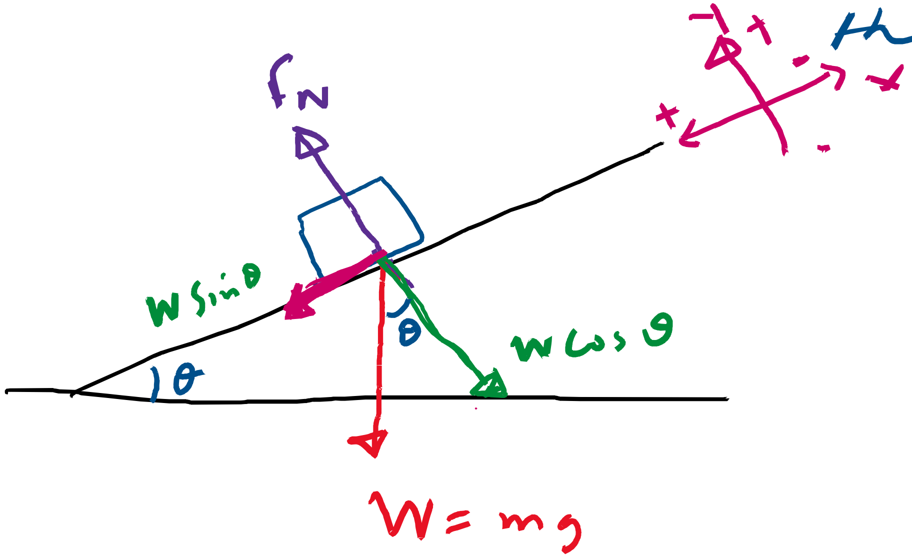


$W\sin\theta = mg\sin\theta$

Consider an object on the incline. Assume the surface is smooth.



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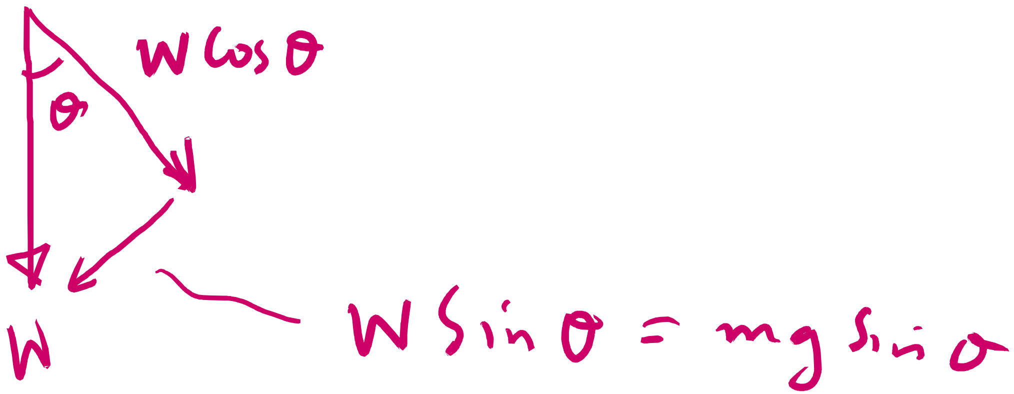
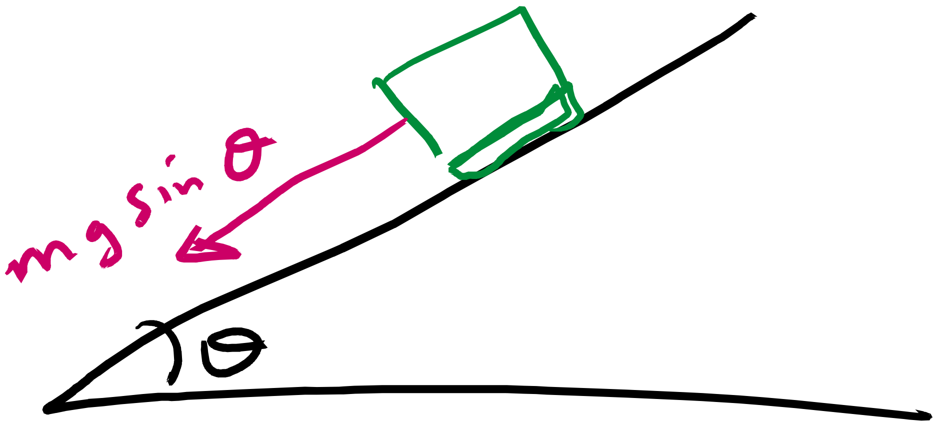
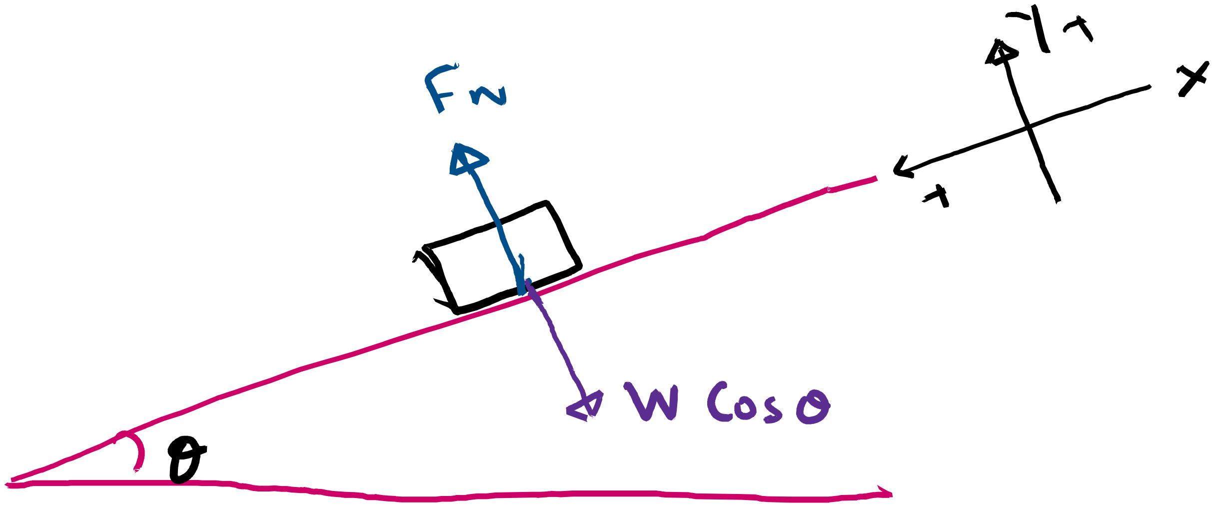


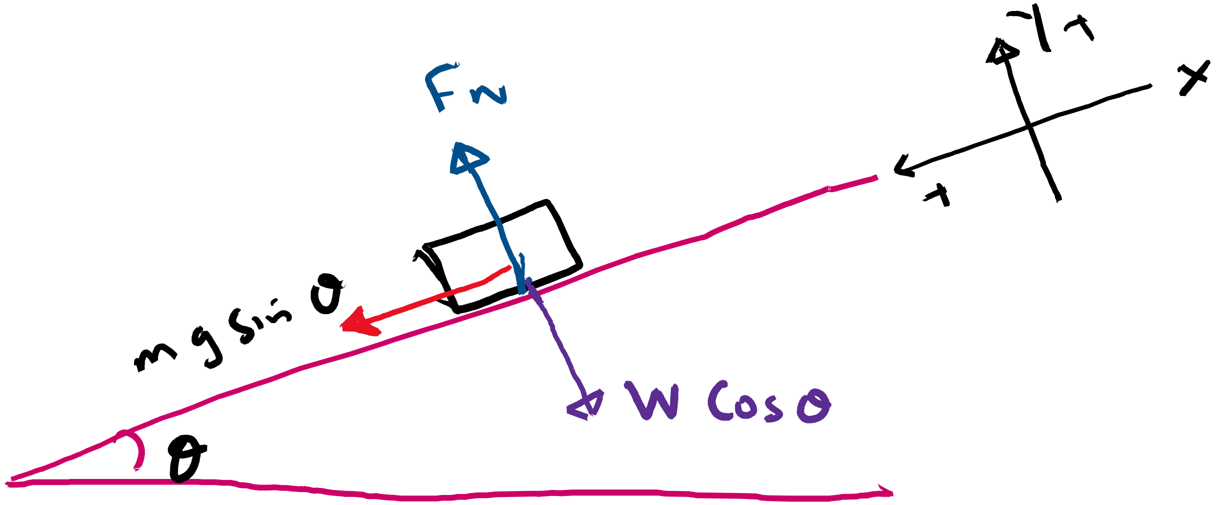
Whenever there is an object on an incline, there is always a force $mg\sin\theta$ that acts down the incline





- There is no motion in the y-direction

$$\therefore \quad F_N = W\cos\theta$$
$$F_N = mg\cos\theta$$



- There is no motion in the y-direction

$\therefore$ $F_N = W\cos\theta$

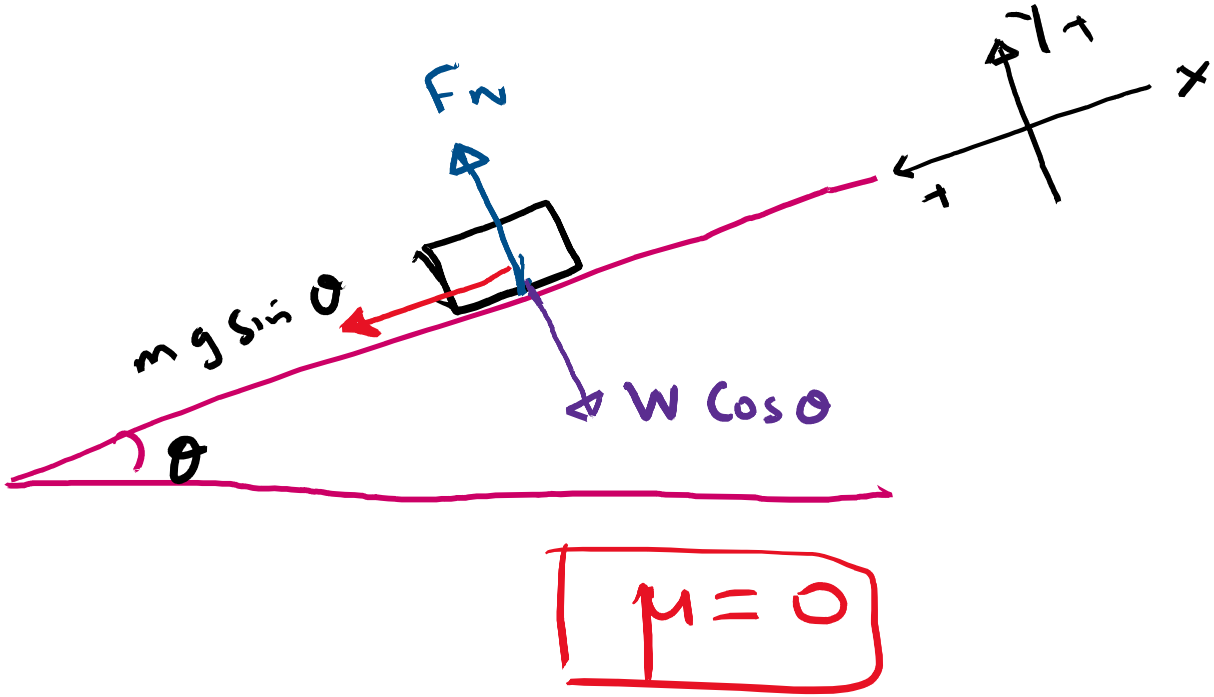
$F_N = mg\cos\theta$

- The force sliding the object is

$F = mg\sin\theta$

$\therefore$ $F = mg\sin\theta = ma$

$a =$



- There is no motion in the y-direction

$\therefore \; F_N = W\cos\theta$

$F_N = mg\cos\theta$

- The force sliding the object is

$F = mg\sin\theta$

$\therefore \; F = \cancel{m}g\sin\theta = \cancel{m}a$

$$\boxed{a = g\sin\theta}$$

acceleration of the object as it slides down.

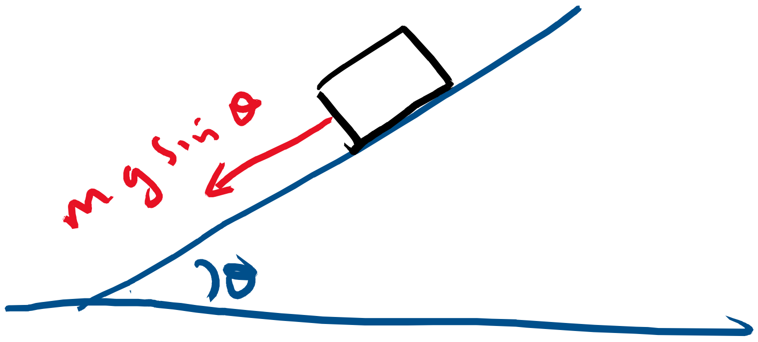
Once you know the acceleration, you can use rectilinear equations to study motion

$$v = u + at$$

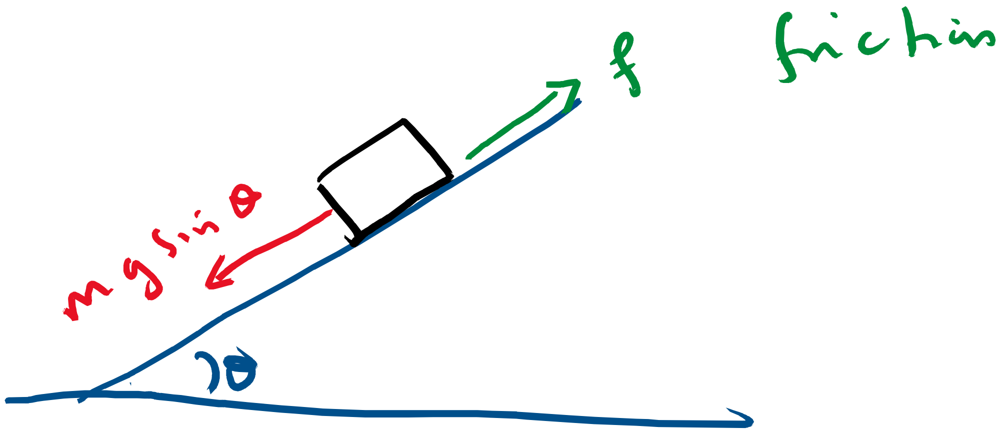
$$v^2 = u^2 + 2as$$

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

Consideration of motion with friction.



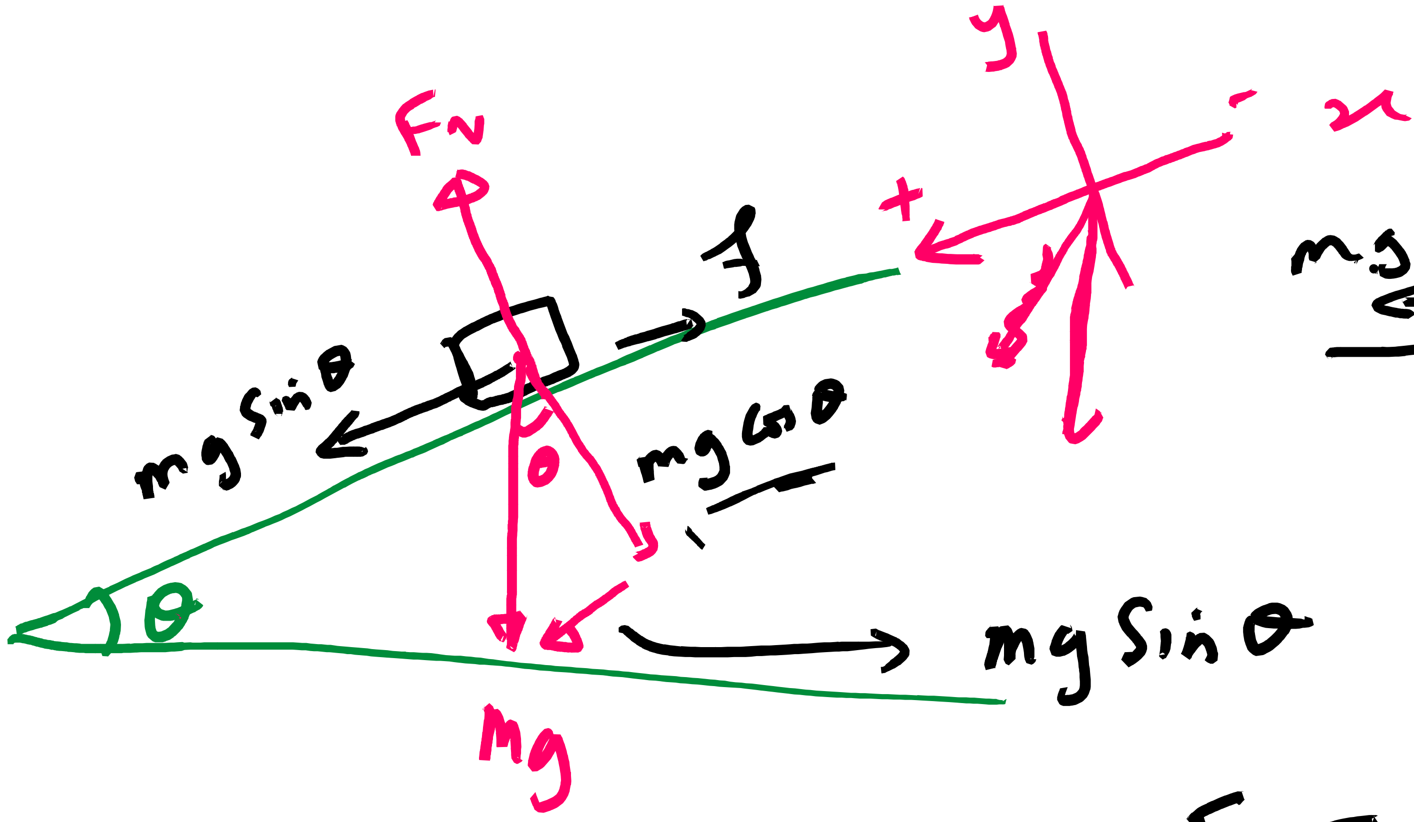
Consideration of motion with friction.

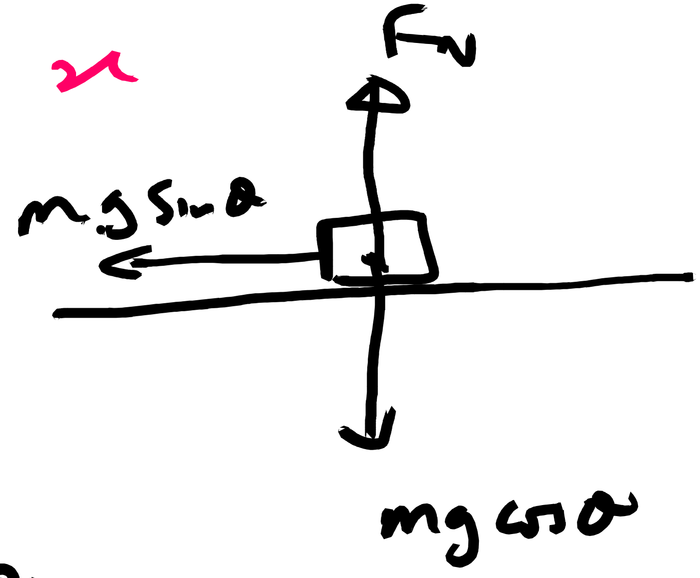


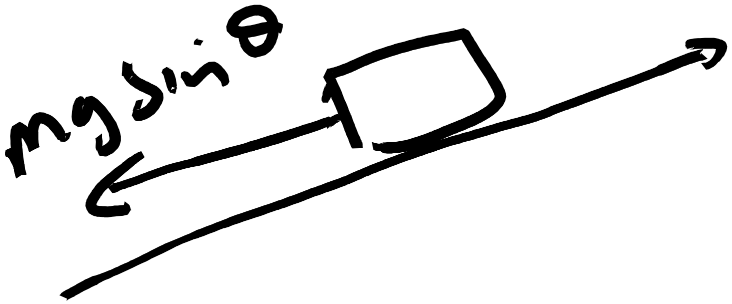
But friction is

$$f = \mu F_N$$

what is F_N.







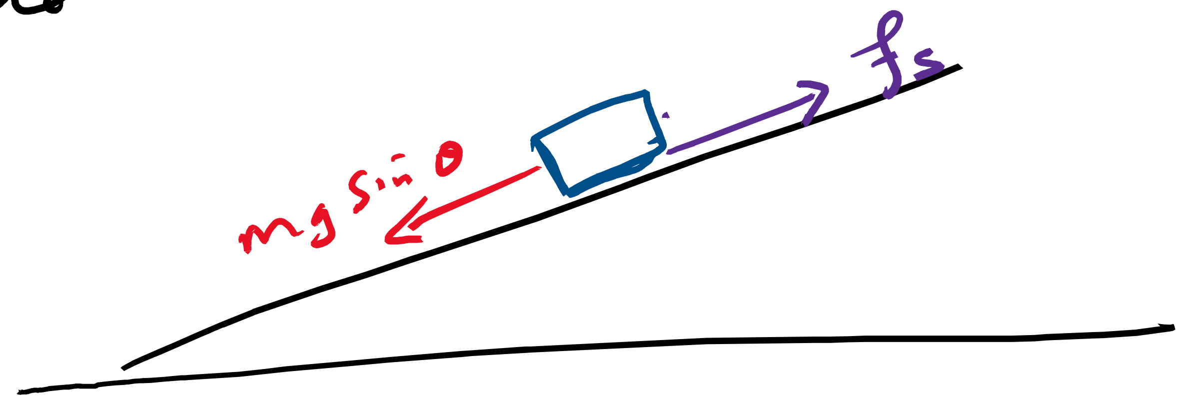
$$F_N = mg\cos\theta$$

$$f = \mu F_N$$

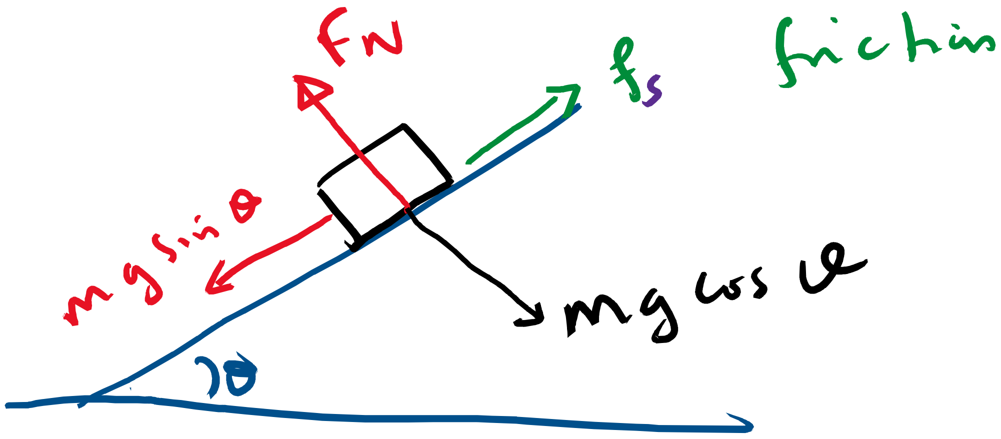
$$= \mu m g \cos\theta$$

Coefficient of static friction and angle of repose.

- friction that acts when the object is just about to slide.



Consideration of motion with friction.



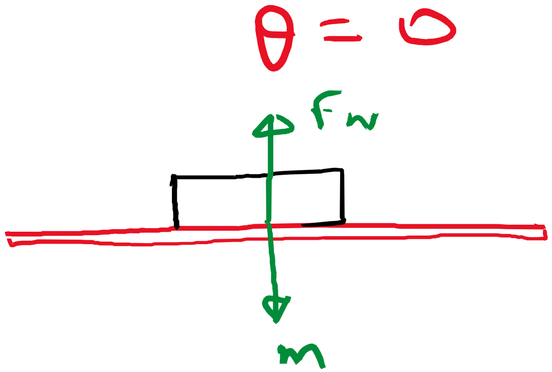
But friction is

$$f = \mu F_N$$

what is F_N.

$$F_N = mg\cos\theta$$

$$\therefore \quad f = \mu mg\cos\theta$$



We found out that

$$F_N = mg\cos\theta$$

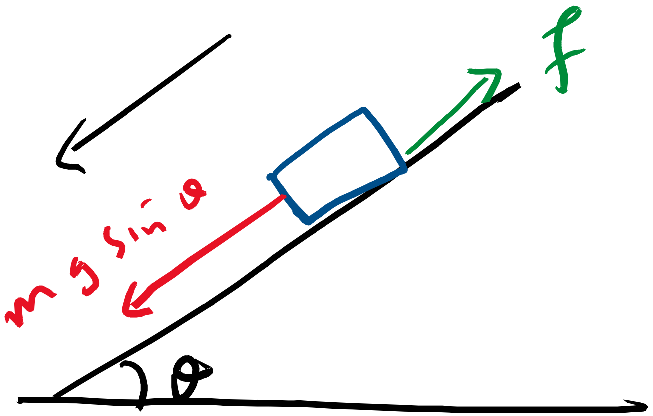
For this case, $\theta = 0$

$$\therefore F_N = mg\cos 0$$

$$F_N = mg \qquad \text{Since } \cos 0 = 1$$

This is the normal force we learnt about for an object on a flat surface.

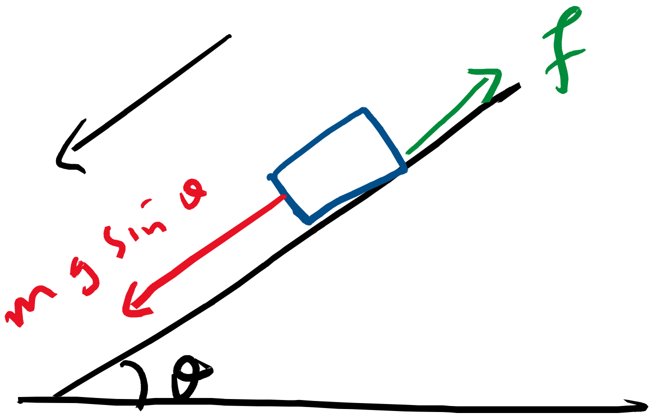
$\therefore F_N = mg\cos\theta$ is a general eqn.



- Using Newton's 2nd law.

$$mg\sin\theta - f = ma$$

$$mg\sin\theta - \mu mg\cos\theta = ma$$



- Using Newton's 2nd law.

$$mg\sin\theta - f = ma$$

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

$$g\sin\theta - \mu g\cos\theta = a$$

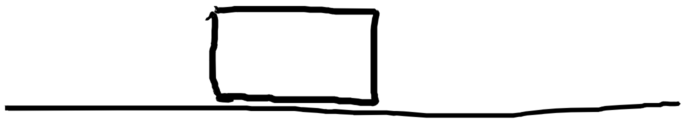
$$a = g\left[\sin\theta - \mu\cos\theta\right]$$

acceleration

when $\mu = 0$: $a = g \sin\theta$

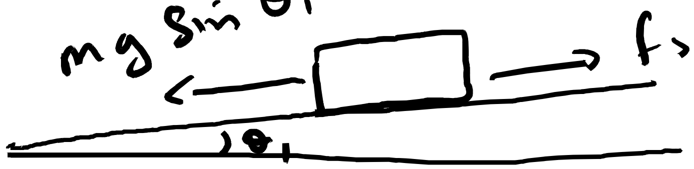
when there is friction : $a = g\sin\theta - g\mu\cos\theta$

Angle of Repose



$\theta = 0$: The object does not move

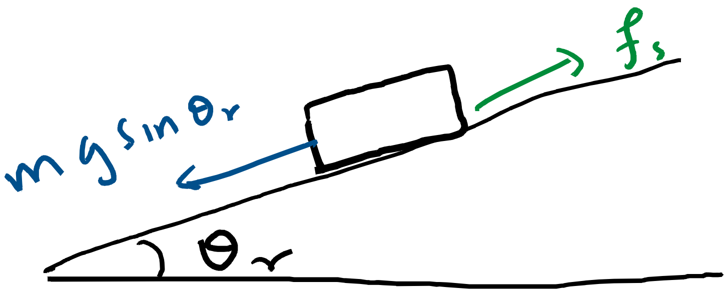
Angle of Repose



$mg \sin\theta_1 < f_s$

$\theta = \theta_1$: The object does not move

Angle of Repose



$$\theta = \theta_r$$

$\because$ $mg\sin\theta_r > f_s$

The object starts moving

The angle at which the object starts moving is called angle of repose.