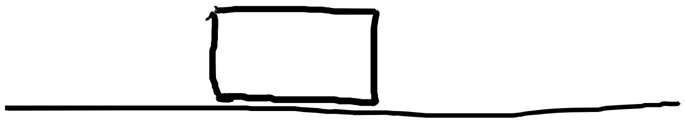
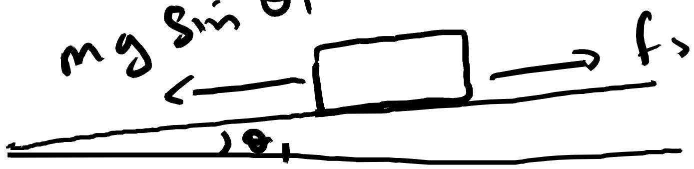
Angle of Repose



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

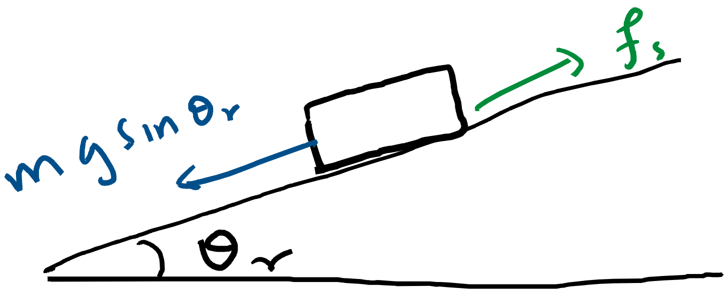
Angle of Repose



$mg\sin\theta_1 < f_s$

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

Angle of Repose



$\theta = \theta_r$:

$mg\sin\theta_r > f_s$

The object starts moving

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

☑ When the object is just about to move there is static friction: μ_s, f_s

$\therefore$ $$mg\sin\theta - \mu_s mg\cos\theta = ma$$

but $a = 0$ since it's just about to move.

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$$\therefore \quad mg\sin\theta - \mu_s mg\cos\theta = 0$$

$\therefore$

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but $a = 0$ since it's just about to move.

$$\therefore \quad \cancel{mg}\sin\theta - \mu_s \cancel{mg}\cos\theta = 0$$

$$\sin\theta - \mu_s\cos\theta = 0$$

$$\mu_s = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$\mu_s = \tan \theta_r$

$\theta_r \equiv$ angle of repose.

- It is dependent on the roughness of the object.

+ A very rough surface has a large angle of repose. You can tilt the surface to a much larger angle before an object begins to slide

+ A smooth surface will have a small angle of repose. You only need a small tilt before it slides.

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

$$v = u + at$$

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

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

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

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

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

$$v = u + at$$

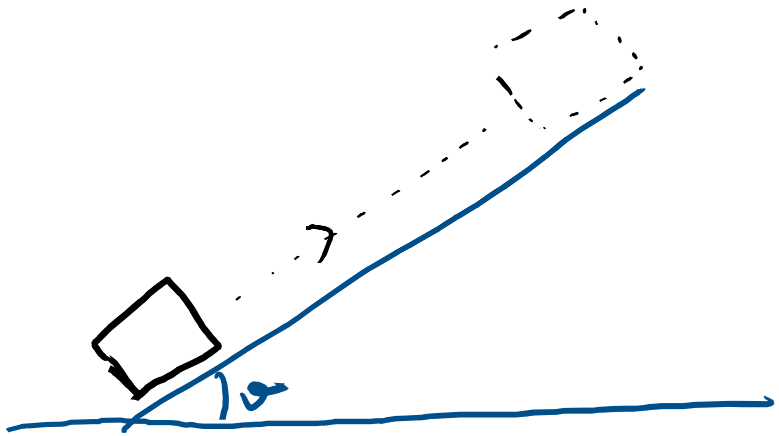
$$v^2 = u^2 + 2as$$

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

Ex: A carton is given an initial speed of 3.0 m/s up the 22° plane. [$\mu = 0$]

a) How far up the incline will it go?

b) How much time elapses before it returns to its starting position



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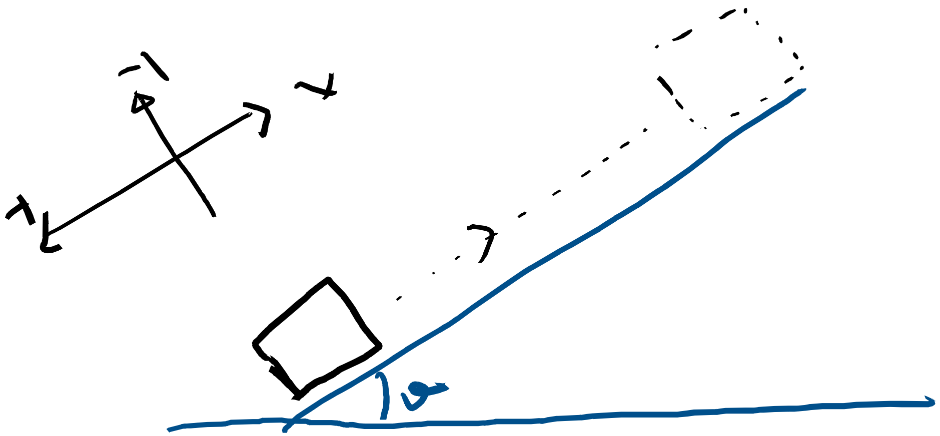

a) $v^2 = u^2 + 2as$

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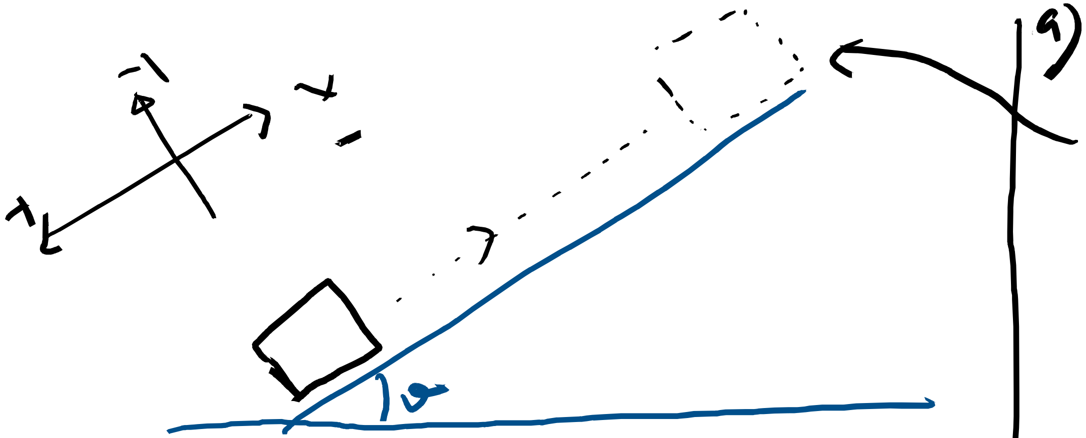

a) $v^2 = u^2 + 2as$

$v = 0$

$u = -3.0\ m/s$

$a = g \sin 22$

$= 3.7$

$\therefore\ 0 = 3.0^2 + 2(3.7)S$

$S = 1.2\ m$

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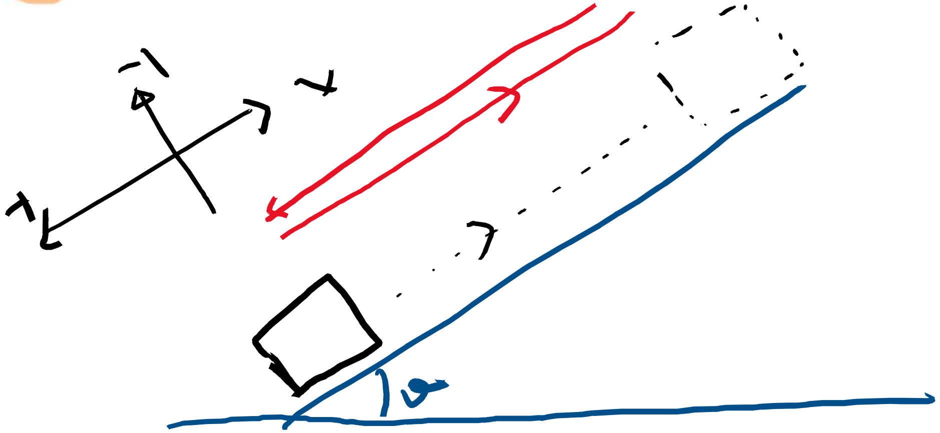


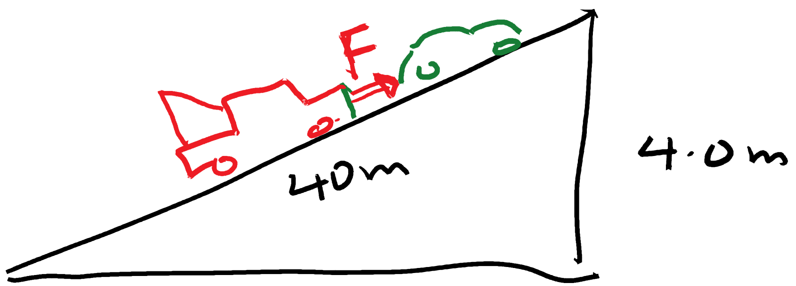
b) $s = 0$

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

$$0 = -3.0(t) + \frac{1}{2} 3.7 t^2$$

$$t = \frac{6}{3.7} = 1.62 \text{ s}$$

A 1200 kg car is to accelerate at 0.5 m/s² up a hill that rises 4.0 m in each 40 m. How large a force must push on the car? [$\mu = 0$]



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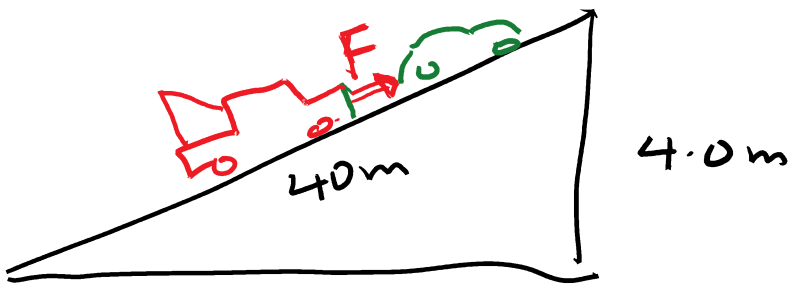
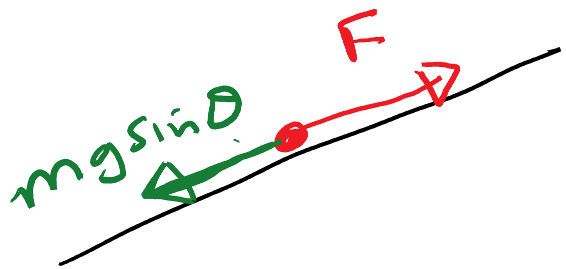


FBD



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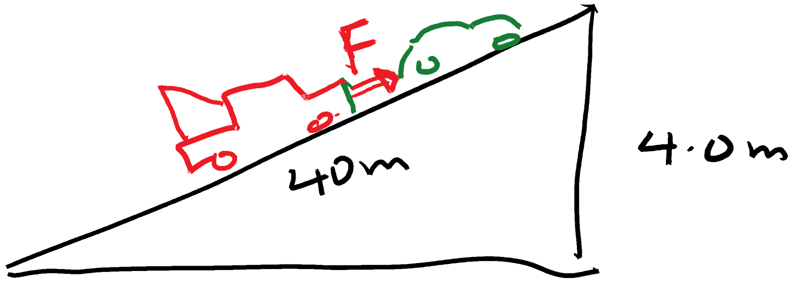
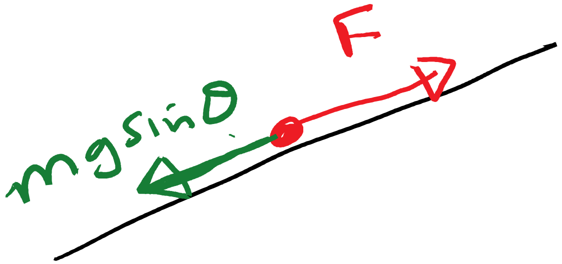
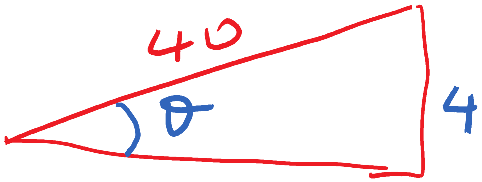


FBD

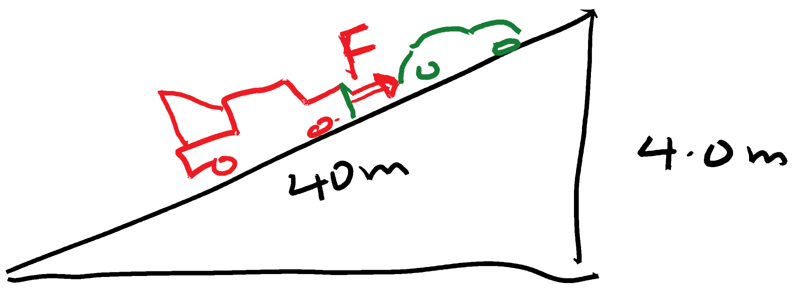


What is sin θ?



$$\sin\theta = \frac{4}{40} = \frac{1}{10} = 0.1$$

A 1200 kg car is to accelerate at 0.5 m/s² up a hill that rises 4.0 m in each 40 m. How large a force must push on the car? [μ=0]



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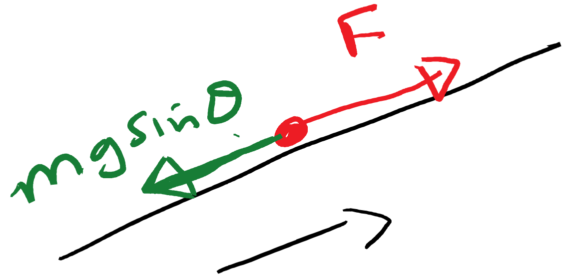


$$\Sigma F = ma$$

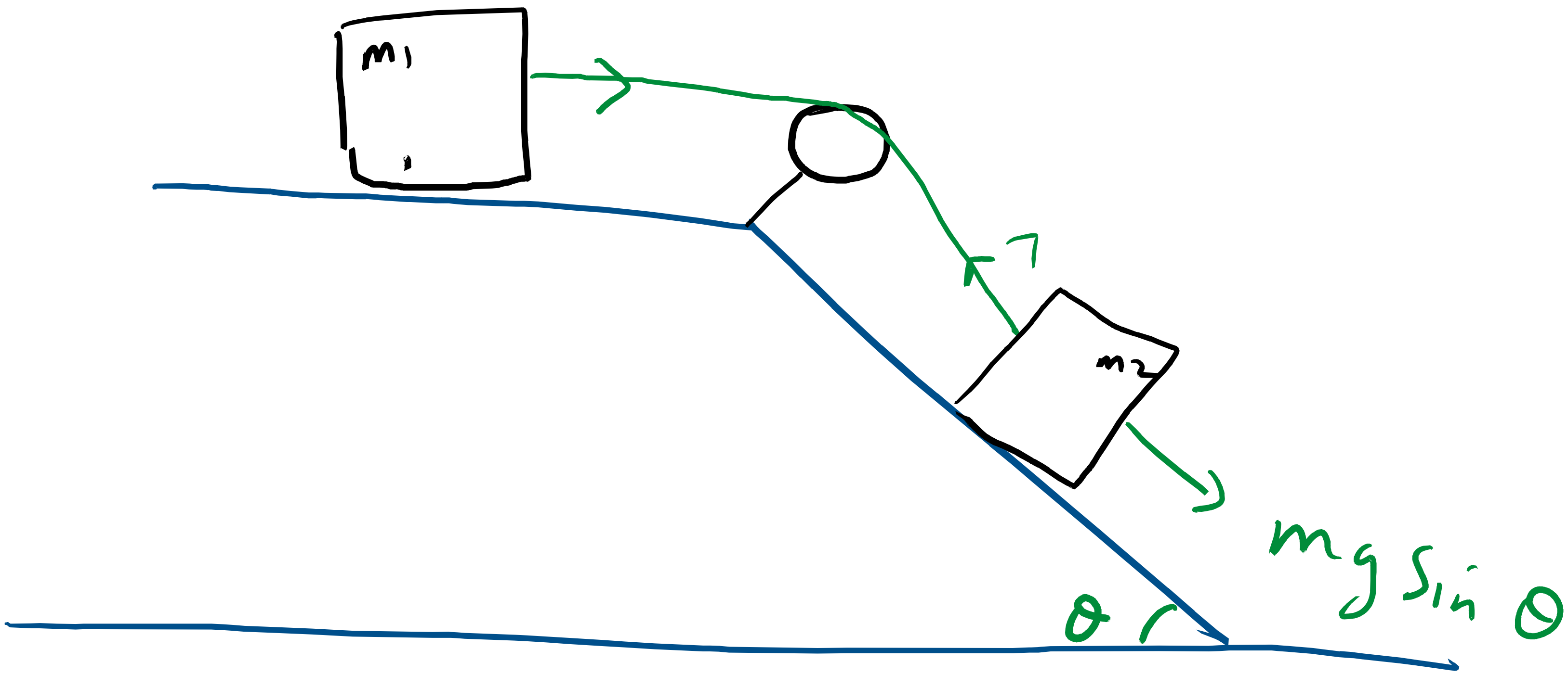
$$F - mg\sin\theta = ma$$

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

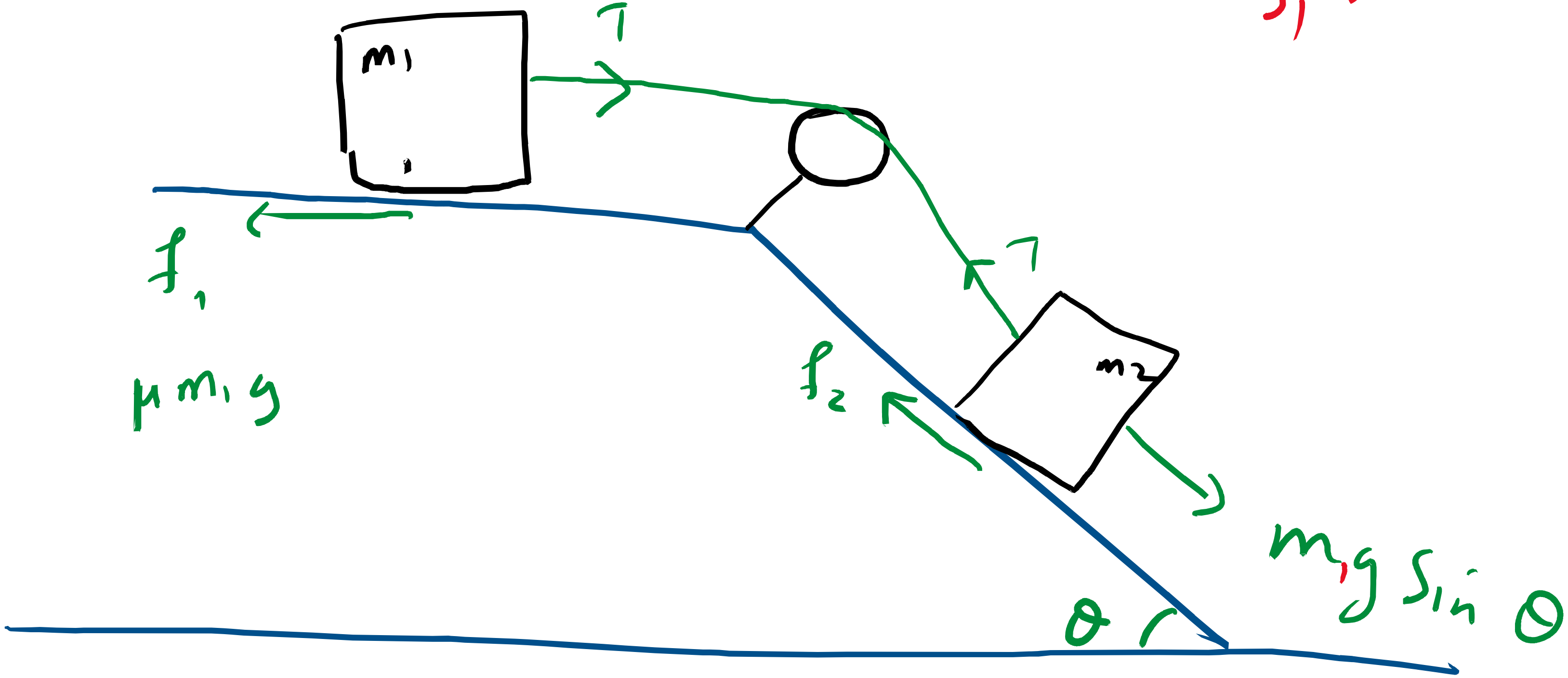
$$= 1200(0.5) + 1200(9.8)(0.1) = 1800\,N$$

(2sf)

Other problems



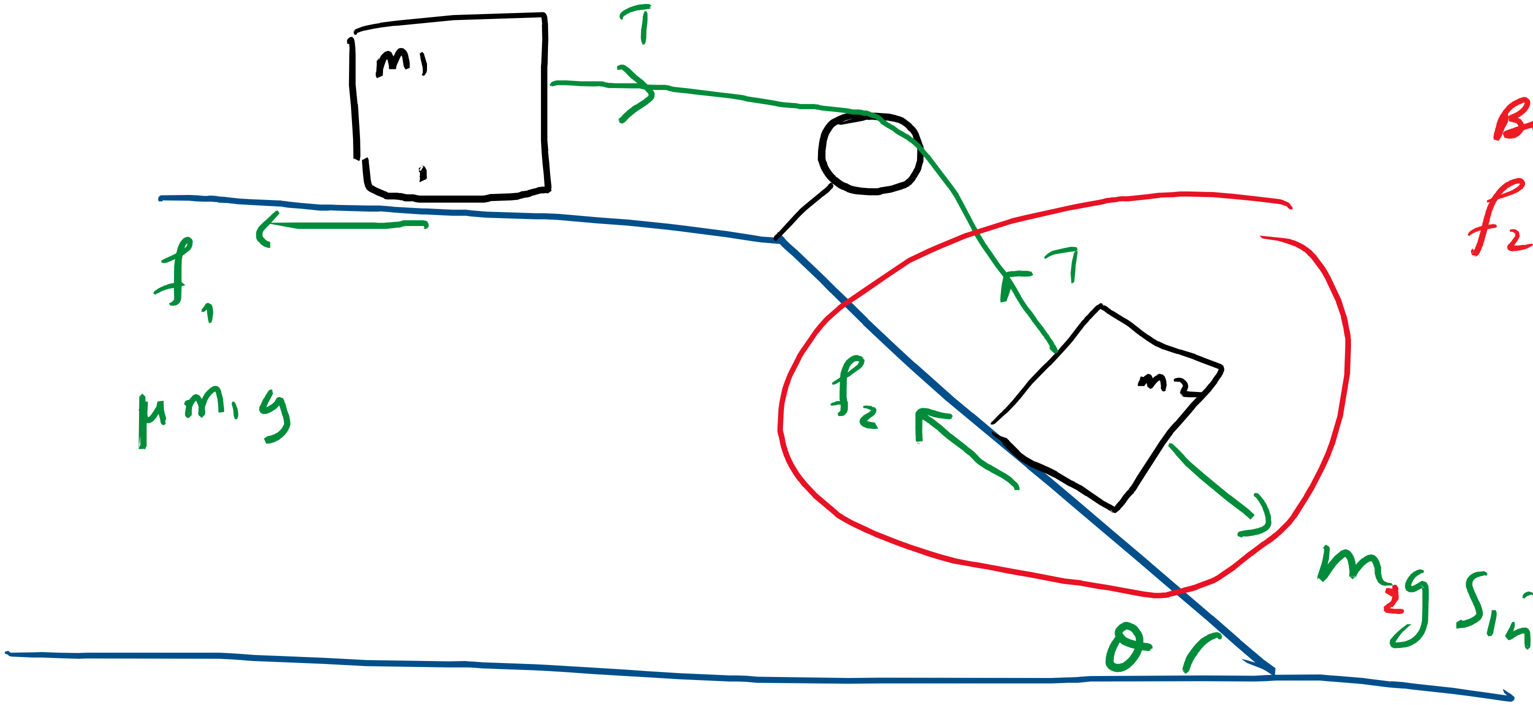
$mg_1 \sin\theta - f_2 - T = m_1 a$

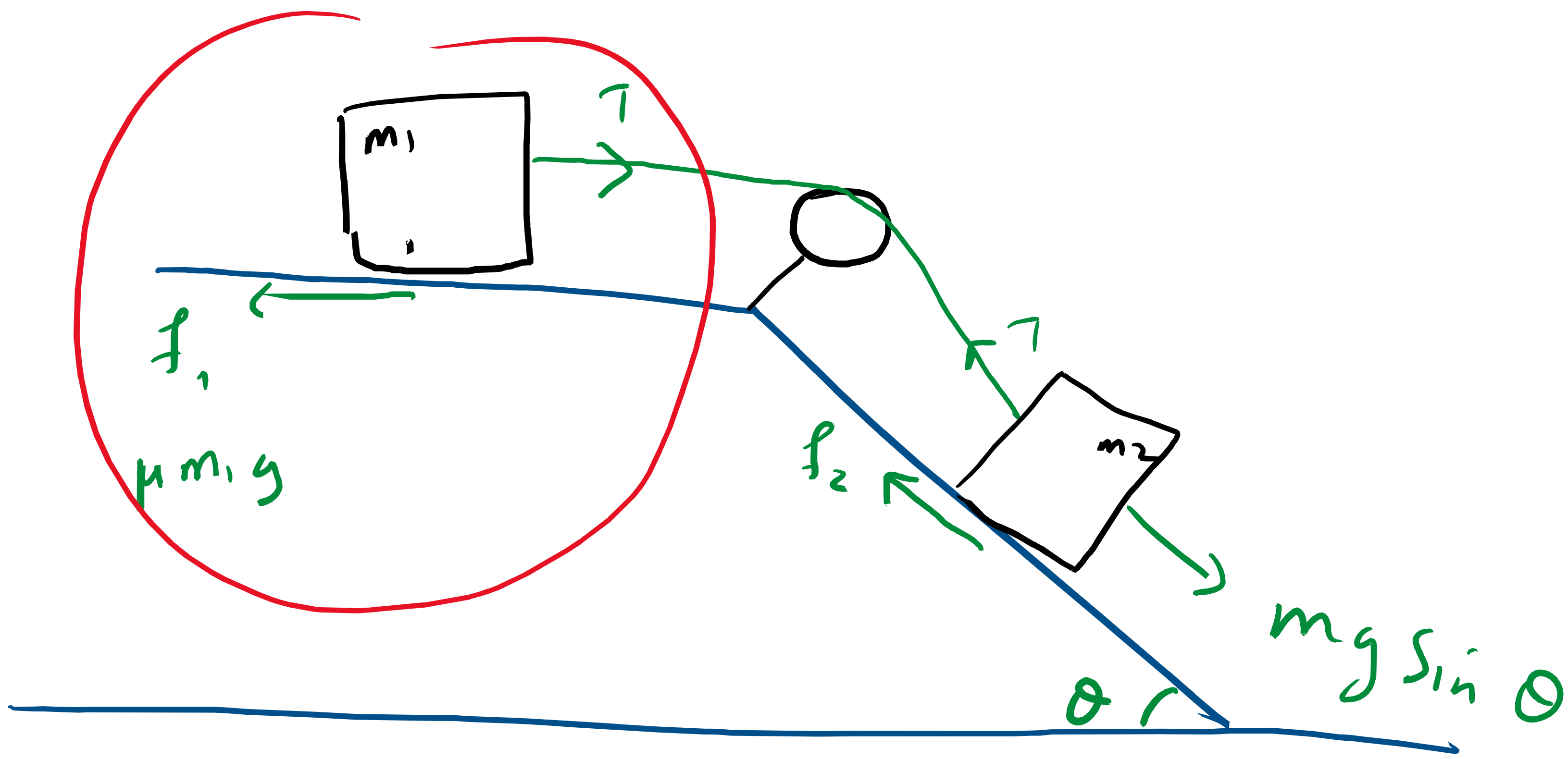


$$m_2 g \sin\theta - T - f_2 = m_2 a$$

But

$$f_2 = \mu m_2 g \cos\theta$$



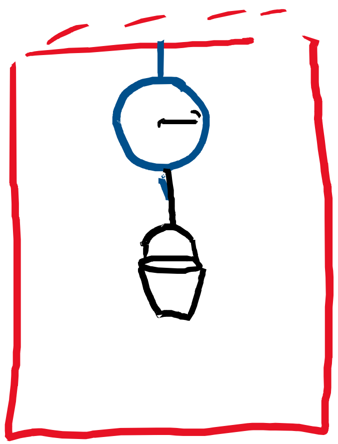


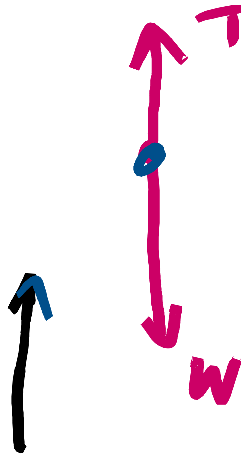
$T - f_1 = m_1 a$

But $f_1 = \mu m_1 g$

Weightlessness

- Observed when objects are accelerating
- Consider a scale and a bucket attached to a roof of the elevator





What is recorded on the scale is the tension

Weightlessness

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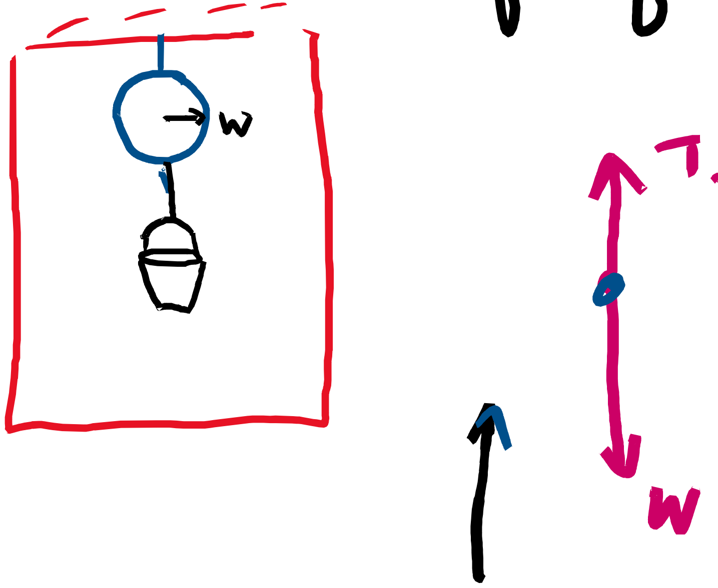


$w = mg$

Case I: when $a = 0$

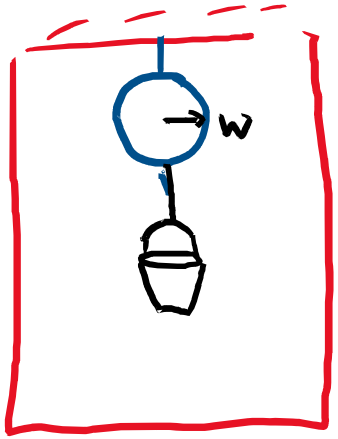
$\Sigma F = ma$

$T - w = 0$: $T = W$

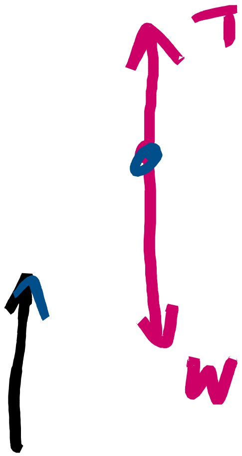
Tension is what is recorded on the scale

Weightlessness

- Observed when objects are accelerating
- Consider a scale and a bucket attached to a roof of the elevator



$w = mg$



Case I: when $a = 0$

$\Sigma F = ma$

$T - w = 0 \therefore T = w$

Tension is what is recorded on the scale

Reflects the actual weight

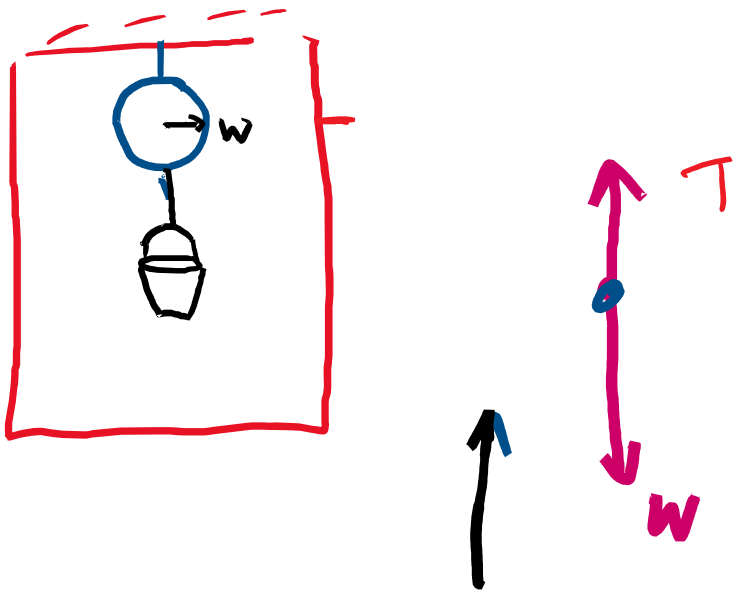
Weightlessness

Case II : Constant Velocity

$$\Sigma F = ma$$

$$T - W = m(0)$$

$$T = W$$



Reflects the actual weight

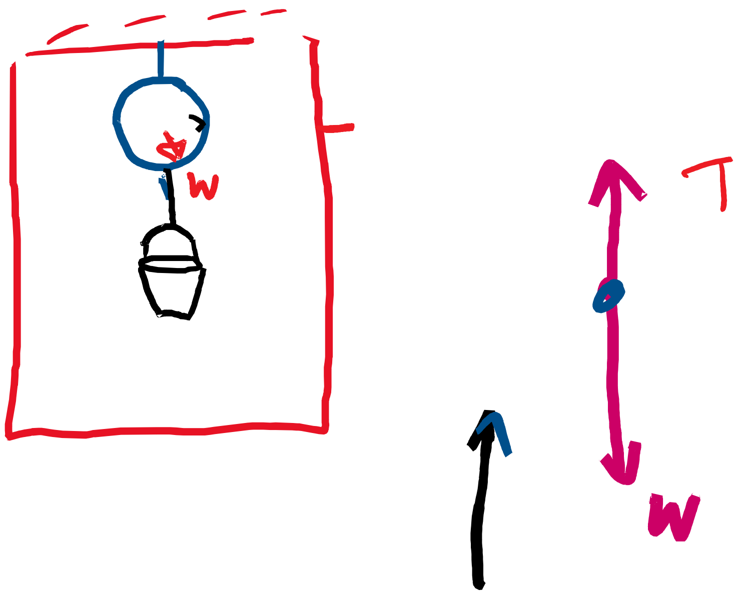
Weightlessness

Case III : Elevator accelerating upwards with a.

$$\Sigma F = ma$$

$$T - W = ma$$

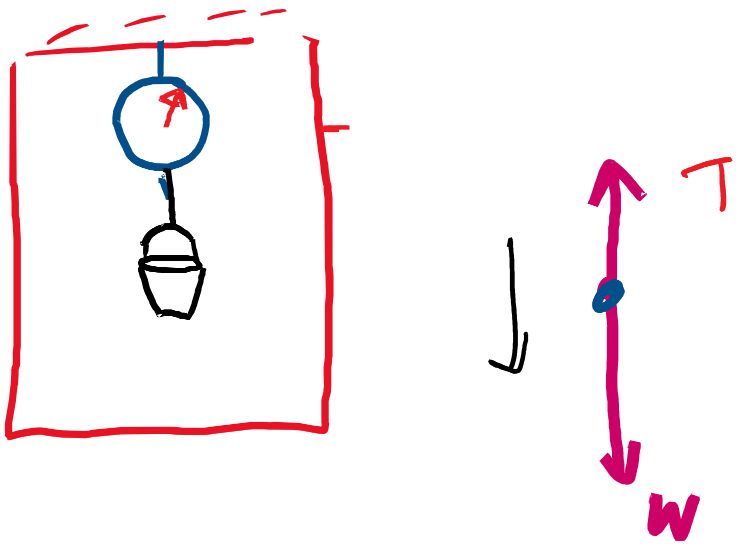
$$\boxed{T = ma + W}$$



The Scale reads mo than the weight of object.

Weightlessness

Case IV : Elevator accelerating downward with a.



$$\Sigma F = ma$$

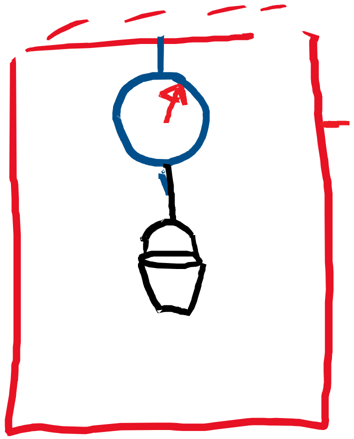
$$W - T = ma$$

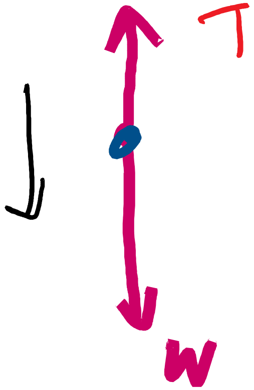
$$\boxed{T = W - ma}$$

Apparent weight ~~...~~ is less.

Weightlessness

Case IV : Elevator accelerating downward with a.





$$\Sigma F = ma$$

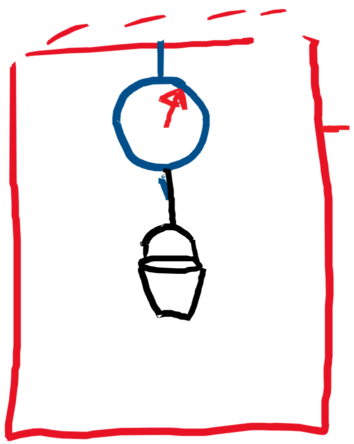
$$W - T = ma$$

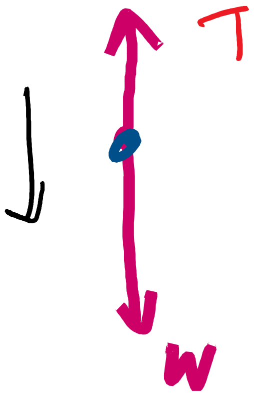
$$\boxed{T = W - ma}$$

Apparent weight ~~w~~ is less.

Weightlessness

Case V Elevator falling with g.





$$\Sigma F = ma$$

$$W - T = mg$$

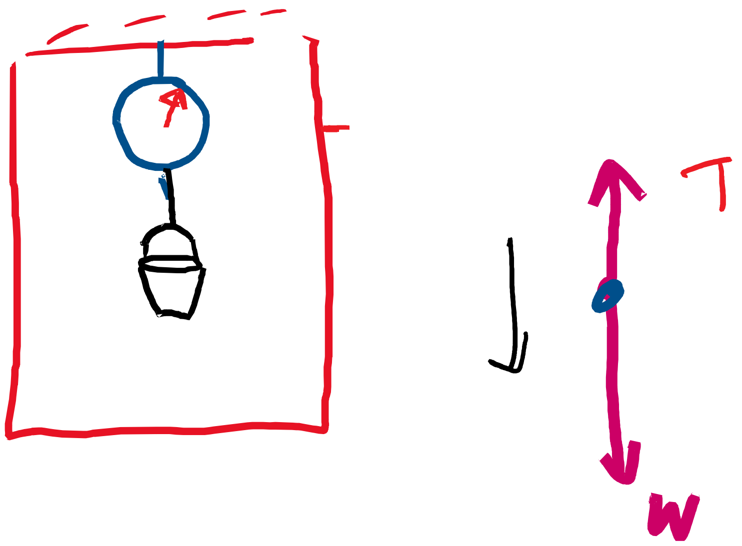
$$T = W - mg$$

$$= mg - mg$$

$$T = 0$$

Weightlessness

Case V Elevator falling with g.



$$\Sigma F = ma$$

$$W - T = mg$$

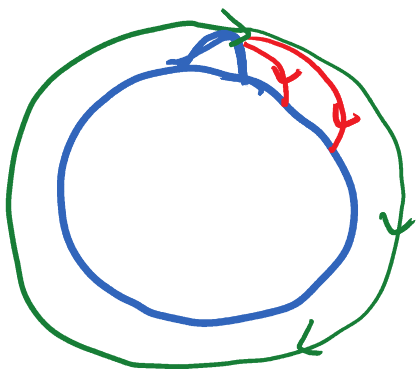
$$T = W - mg$$

$$= mg - mg$$

$$T = 0$$

Weightless !!

The astronauts at the International Space Station feel weightless not because there is no gravity but because they are falling with g.



falling at the same rate as the curvature of the earth