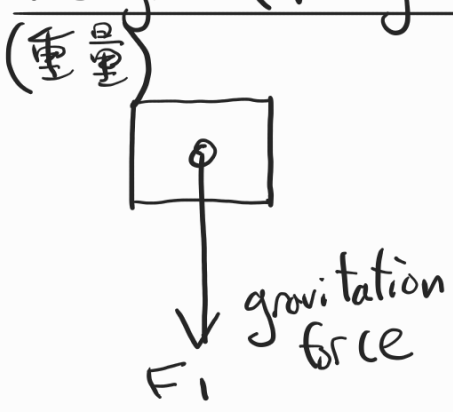
Physics 2.2 - Force

Force is a vector. SI unit: Newton N (牛頓)

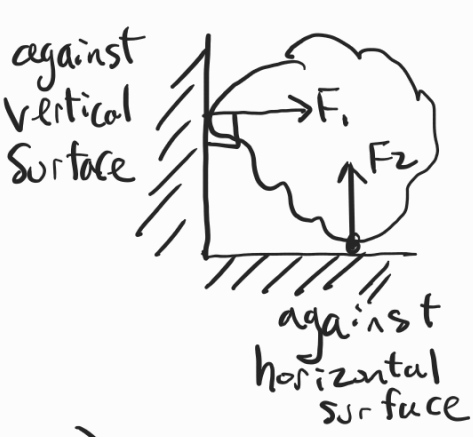
some commonly used force:

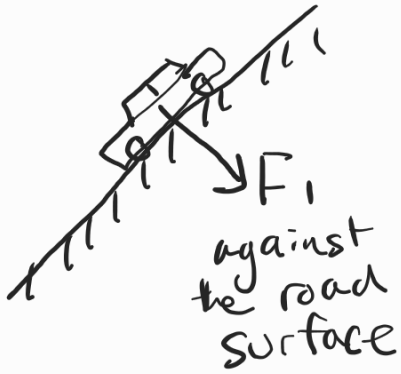
Weight (due to gravity)

(重量)



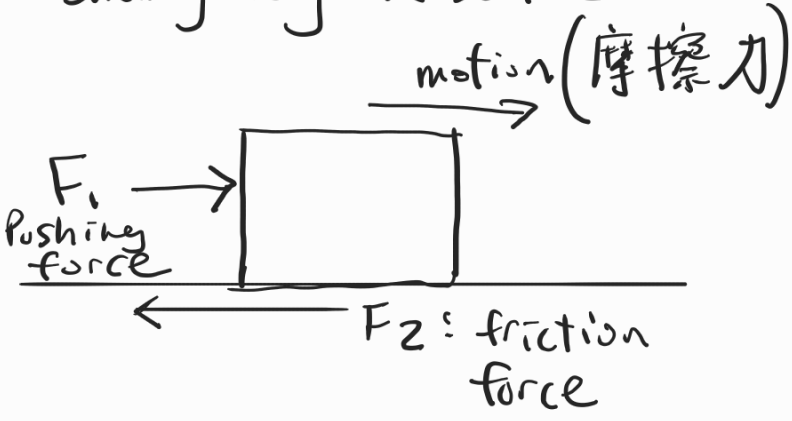
Normal Force (⊥ to contact surface)



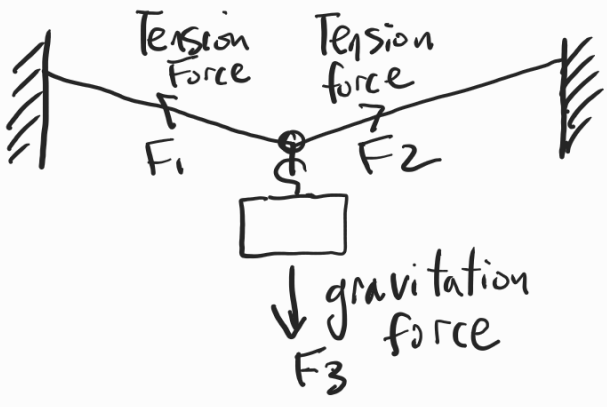


Friction (oppose the motion)

sliding along the surface

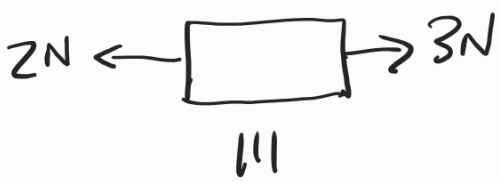


Tension (張力)

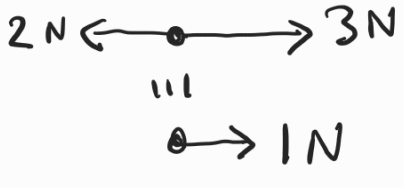


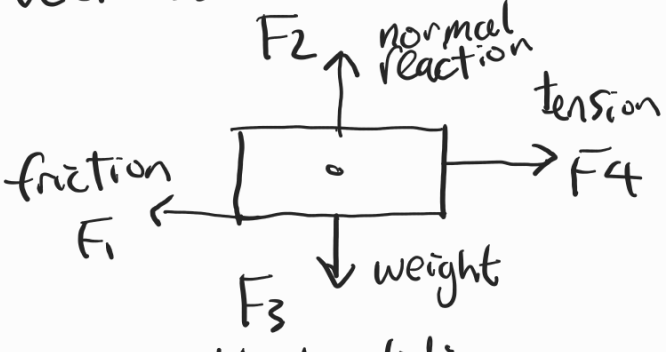
Net Force (Sum up all force vectors)

(淨力)



add 2 force vectors together



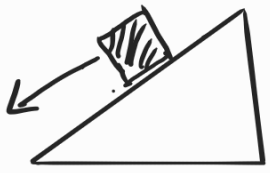


e.g. a block sliding on table surface (Free body diagram)

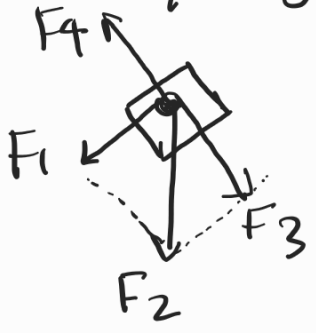
How to draw a free body diagram

- Draw only the object
- Draw only the force vectors acting on this object
- Never draw the net force
- Label the force vectors with symbols: e.g. f_g, f_x, f_y

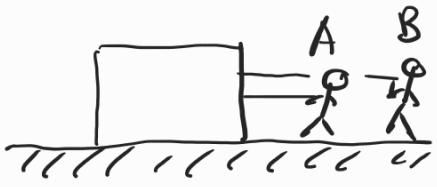
e.g. a box sliding down



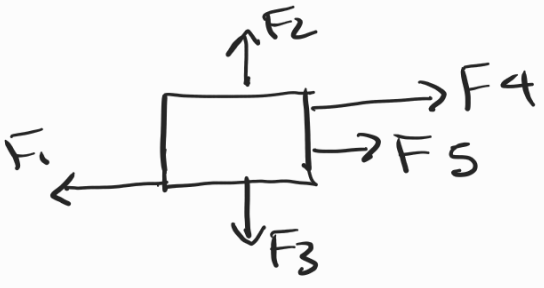
free body diagram



e.g.

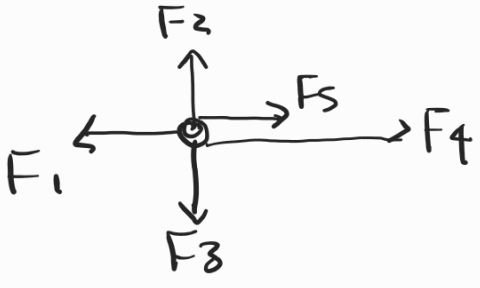


Two men pulling a block (with friction)



F_1: friction force
F_2: Acting force on road
F_3: Weight, gravitation force
F_4: Pulling force by A
F_5: Pulling force by B

The net force is obtained by adding all vectors



since $F_2 = F_3$

Net force $= F_4 + F_5 - F_1$

Newton's first law of motion

An object remains <u>at rest</u> or moves at <u>constant velocity</u> if net force is zero (i.e. $F_{net} = 0 \Rightarrow a = 0$)

or

An object maintains present state of motion at $F_{net} = 0$
resist change of motion (慣性, inertia)

Mass (重量) : SI unit kg

Newton's second law of motion

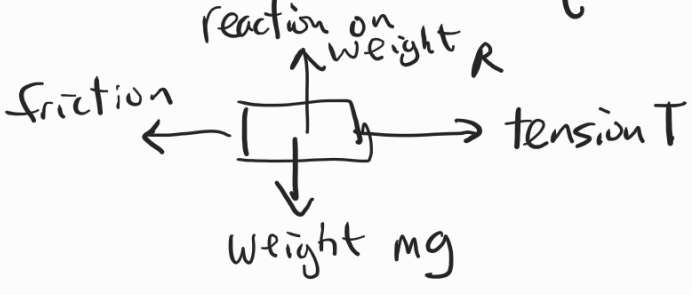
Net Force = mass × acceleration ($F_{net} = m \times a$)

Unit of force N : $(kg) \times (ms^{-2}) \Rightarrow 1N = 1\,kgms^{-2}$

<u>Example:</u> Dogs pulling a sledge (雪橇) on ice

Acceleration : 0 to $10ms^{-1}$ in 5 s
Friction on ice surface : 100 N
Mass of stedge with passengers : 400 kg
Find the tension of the rope pulled by the dogs.

<u>Solution:</u> $a = \frac{v-u}{t} = \frac{10-0}{5} = 2ms^{-2}$



$R = mg$ $F_{net} = T - f$

$T - f = ma$
$T - 100 = 400 \times 2$
$\therefore T = 900N$ //

Weight and Mass

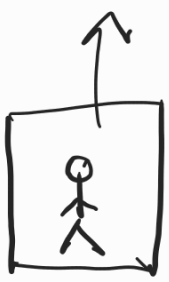
weight can be treated as a force vector due to gravity

$$F_{weight} = W = m\,g$$

m: mass; g: $9.81\ ms^{-2}$

Example : find the apparent weight

elevator 電梯

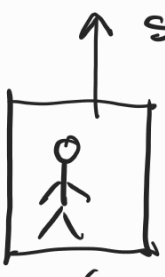


constant velocity

$a = 0$

R = weight = mg

speeding up



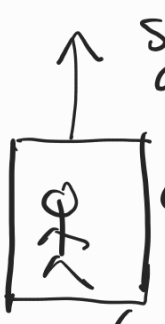
$a = 1\ ms^{-2}$

$R = (9.81 + 1) \times m$

$(g + a) \times m$

more heavier

slowing down



$a = -1\ ms^{-2}$

$R = (9.81 - 1) \times m$

$(g - a) \times m$

lighter

IQ question

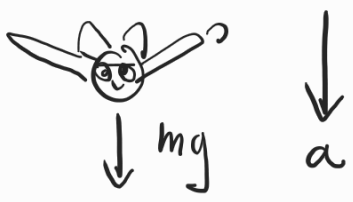
what happens when the elevator (i) accelerates at $1g$?

(ii) decelerates at $1g$?

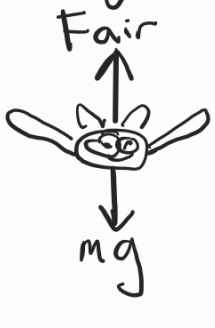
Fluid resistance (流體阻力)

Skydiver jumps from a plane

stage 1

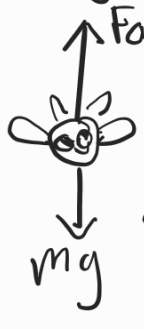


stage 2



$a = mg - F_{air}$

stage 3



$mg = F_{air}$

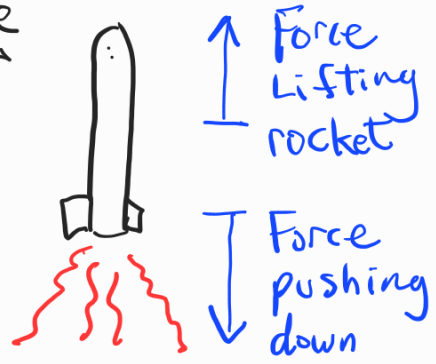
$a = 0$

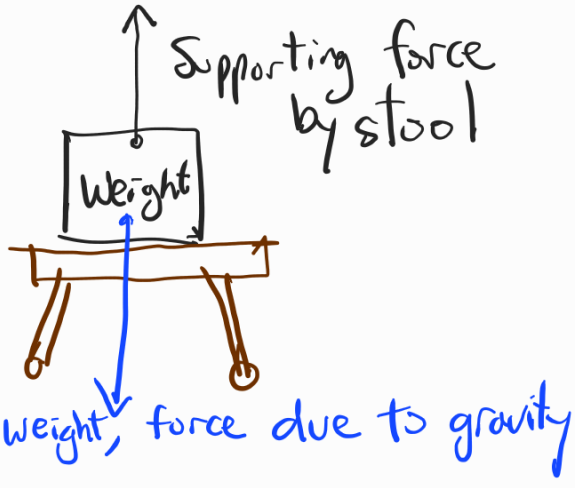
constant speed

Newton's third law of motion

When object A exerts a force on B, B will exert an equal and opposite force on A at the same time. (action - reaction)

Example





Note: These two forces are equal + opposite and happen at the same time