With 2019 NCEA Exam included

Part Two

2020 Version

NCEA Science 1.1
Mechanics AS 90940

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Achievement Criteria

AS 90940 S1.1

Aspects of mechanics will be limited to a selection from the following:

- Distance, speed, interpretation of distance and speed time graphs, average acceleration and deceleration in the context of everyday experiences such as journeys, sport, getting going.
  The relationships $v = \frac{\Delta d}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$.
- Mass, weight and the acceleration due to gravity, balanced and unbalanced forces, in the context of everyday experiences such as being stationary, moving at constant speed, accelerating. The $F_{net} = ma$.
- Force and pressure in the context of everyday experiences.
  The relationship $P = \frac{F}{A}$.
- Work and power, gravitational potential energy, kinetic energy, and the conservation of mechanical energy in free fall situations in the context of everyday experiences such as sports performance, dropping things, tossing balls.
  The relationships $\Delta E_P = mg\Delta h$ $E_K = \frac{1}{2}mv^2$ $W = Fd$ $P = \frac{W}{t}$.

Force, mass and acceleration

The Force experienced by an object can be calculated by multiplying the mass of the object by its acceleration.

Force = Mass x Acceleration

If more force is applied to an object then it will accelerate faster

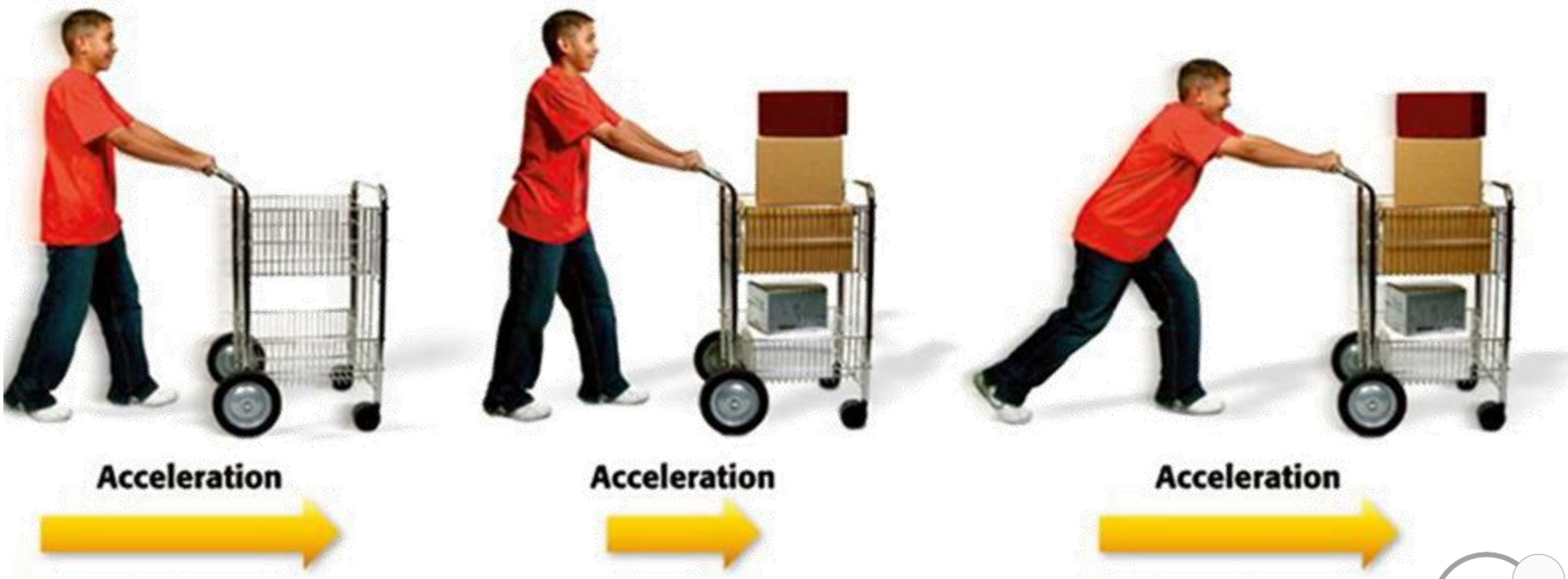
$$F = ma$$

a = acceleration (ms^{-2})
F= force (N)
m = mass (kg)

Acceleration of a body depends both on its mass and on the size of the unbalanced force acting on it

Force = Mass x Acceleration

If the same amount of force is applied to two similar objects that have different mass, then then smaller object will accelerate faster.



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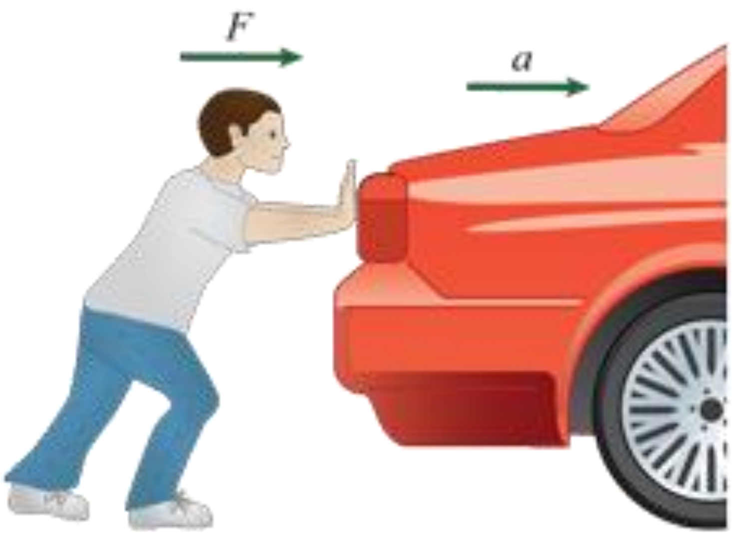
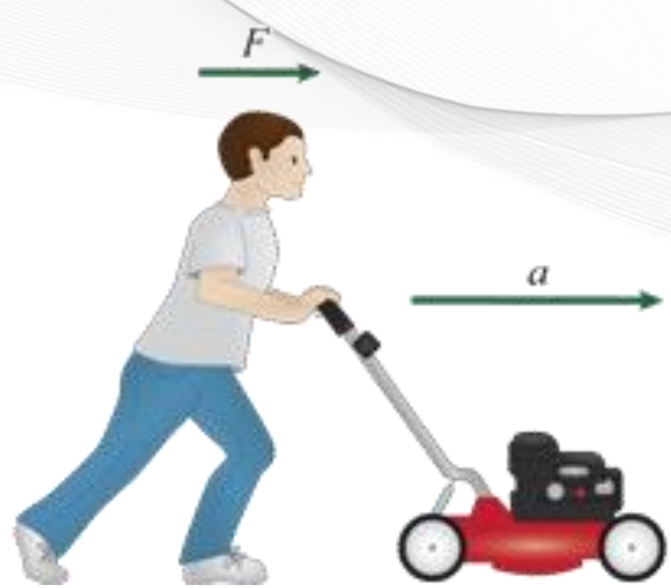
F = ma calculations





Ben is able to push both the car and the lawn mower so they accelerate at $0.5ms^{-2}$. The mass of the car is 950kg and the mass of the lawn mower is 10kg. What is the force required to accelerate the car compared to the lawn mower?

Car

F=ma

F=950kg x $0.5ms^{-2}$

F= 475N

lawn mower

F=ma

F=10kg x $0.5ms^{-2}$

F= 5N

F=ma

a = acceleration (ms^{-2})

F = force (N)

m = mass (kg)

NCEA 2012 Force - The Tractor

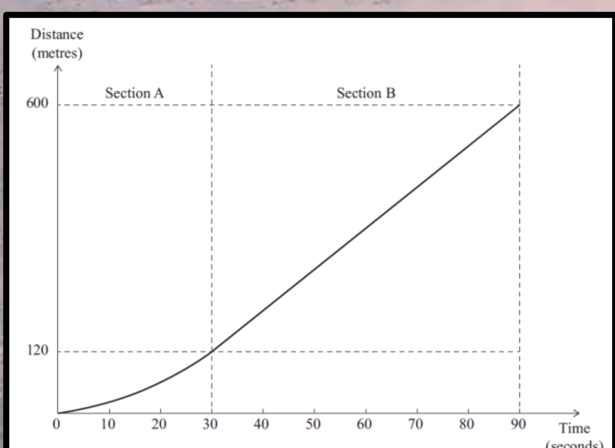
Excellence Question

The total mass of the tractor and driver is 1660 kg.
Calculate the **speed** of the tractor at the **end** of section A, and then calculate the **net force** acting on the tractor during **section A** of the graph.

Slope of section B = speed of tractor at end of section A = rise/run = 480 / 60 = 8 m s^{-1}

$a = \Delta v / \Delta t = (8 - 0) / 30 = 0.27$ m s^{-2}

$F = ma = 1660 \times 0.27 = 448.2$ N



Background Knowledge

Newton's Laws

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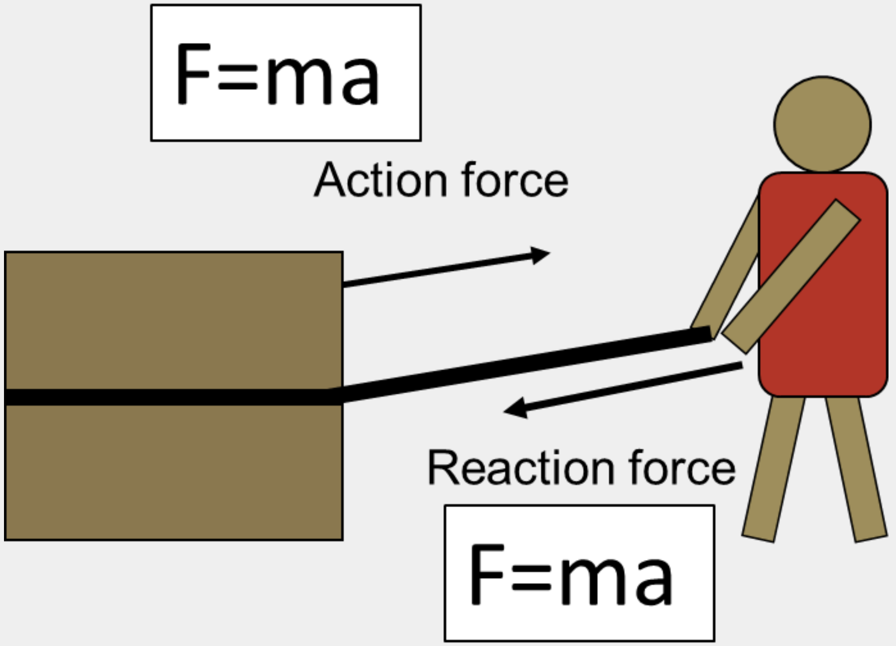
Third Law

When a force acts on an object, an equal and opposite reaction force occurs. This is called action-reaction.



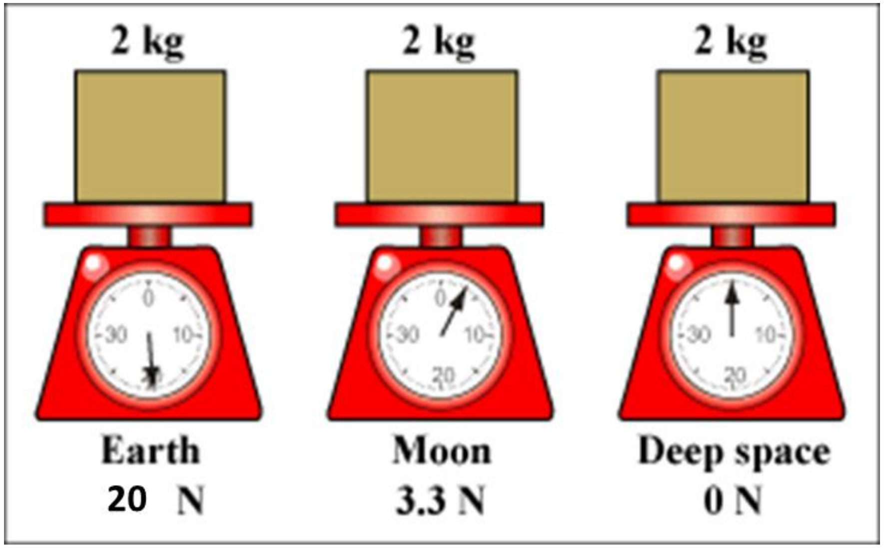
Mass and Weight

All objects have **Mass**. Mass refers to the amount of atoms, or substance, in an object. The formula symbol for mass is **m**.

Mass is measured in kilograms (kg). 1kg = 1000g

The mass of the object remains the **same** regardless of its **location**.

Weight is the downward force due to gravity that an object experiences due to its mass. The weight of an object depends on its location and the **gravity** pulling down on it. The weight of an object can change depending on where it is located. Astronauts weigh less on the moon because the force of gravity is less, but their mass is the same in both locations. The formula symbol for weight is F_w (weight force). Weight is measured in **Newton's** (N)



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Converting between Mass and weight

To calculate the weight (or the downward force due to gravity) you need to multiply the objects mass by the acceleration due to gravity.

On Earth, due to the size and mass of the planet, we experience a gravitational pull of $10ms^{-2}$

This means if we were to freefall to Earth, every second we would accelerate 10m more per second – 1 second fall 10m, the next second fall 20m, the next second fall 30m etc.

Converting mass to weight

$$F_w = mg$$

g = acceleration due to gravity = ($10ms^{-2}$)

F_w= Weight force (N)

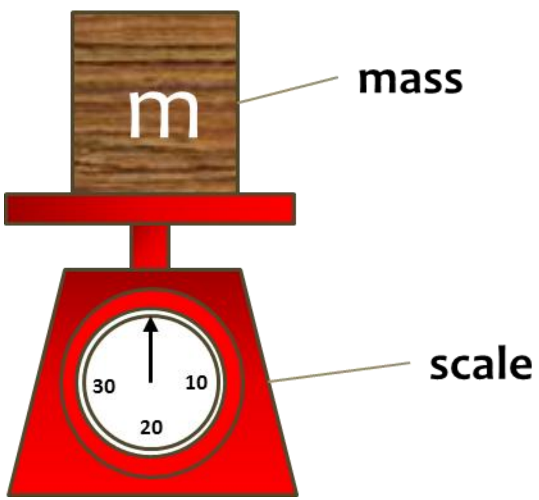
m = mass (kg)

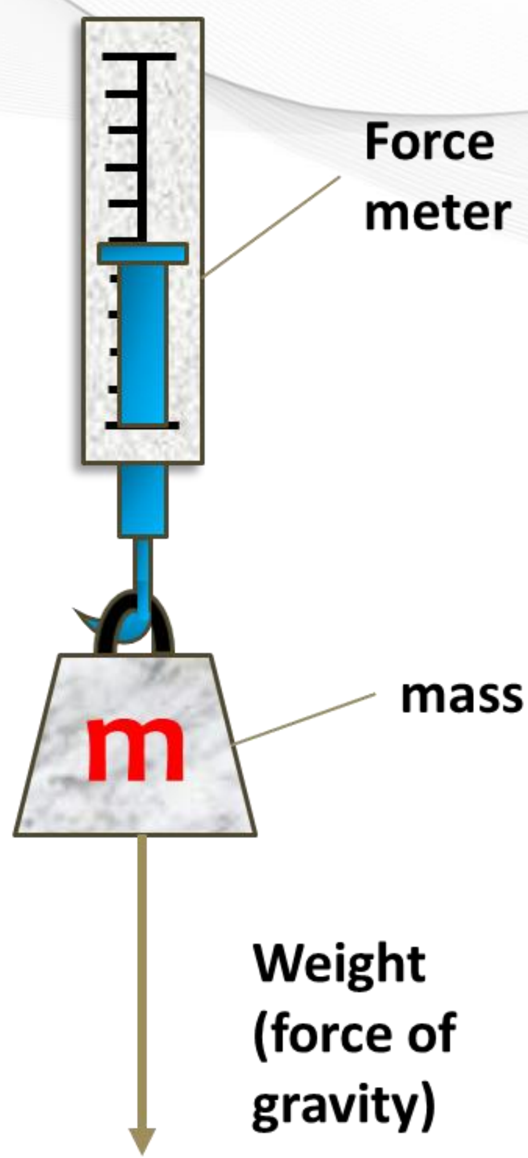
This is still the **F = ma** formula

Measuring Mass and weight

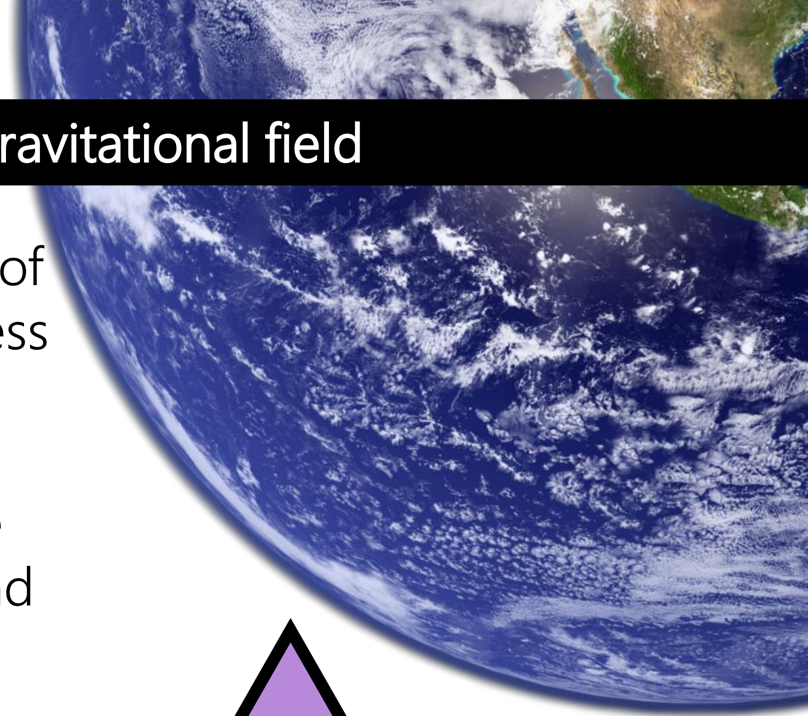
Weight can be measured with a spring balance, where the mass can vertically hang and the weight can be read off the force meter. The scale will be in Newtons (N).
A 2kg mass would read as (2 x $10ms^{-2}$) **20N**

Mass can be measured with scales, where the mass can sit on top and the mass can be read off the meter. The scale will be in kilograms kg (or grams)





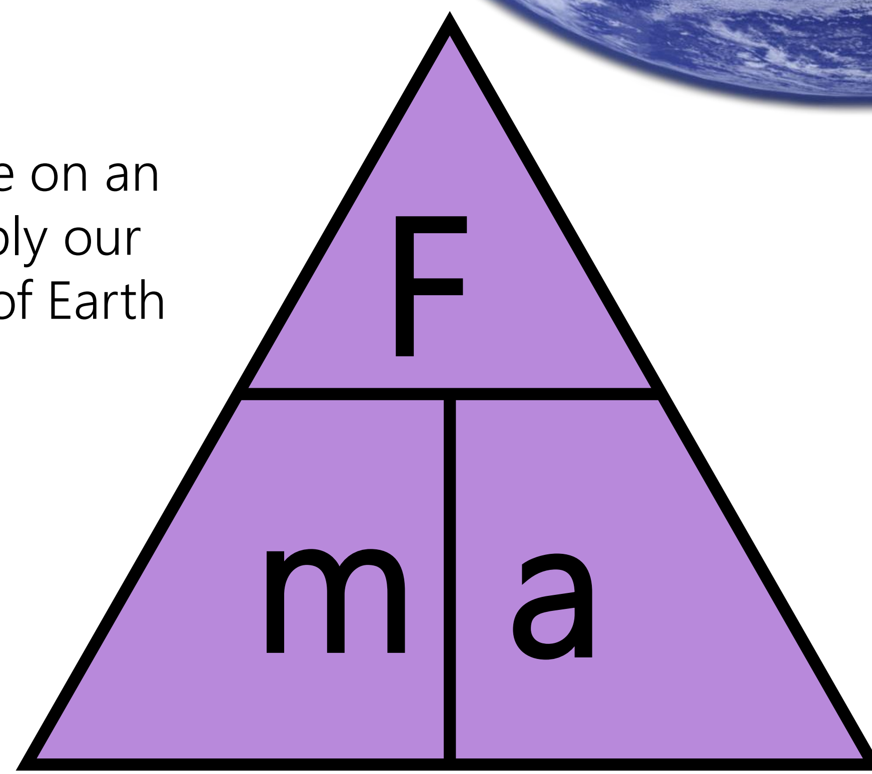
The Earth is the source of a gravitational field



The mass of the Earth creates an acceleration of 10 ms^{-2} for objects falling towards it. Regardless of the size of the object, they all fall with the same acceleration - only the shape, which causes changes in air resistance, causes some objects to experience more opposing force and accelerate slower.

To calculate our weight, which is a force on an object in a gravitational field, we multiply our mass by the gravitational acceleration of Earth (10ms-^{2})

We use a g value of 10ms^{-2} at this level



NCEA Mass and Weight – the warehouse

Q1: A box in a warehouse has a mass of 2 500 kg. assuming $g=10ms^{-2}$
(a) Explain the difference between weight and mass.
(b) Calculate the weight of the box.

Weight is the downward force due to gravity that an object experiences, while mass is a measure of the amount of matter that an object has.

$F_{\text{weight/gravity}} = mg$

$= 2\ 500 \times 10 = 25\ 000$ N

NCEA 2015 Mass and Weight - The kererū

Merit Question

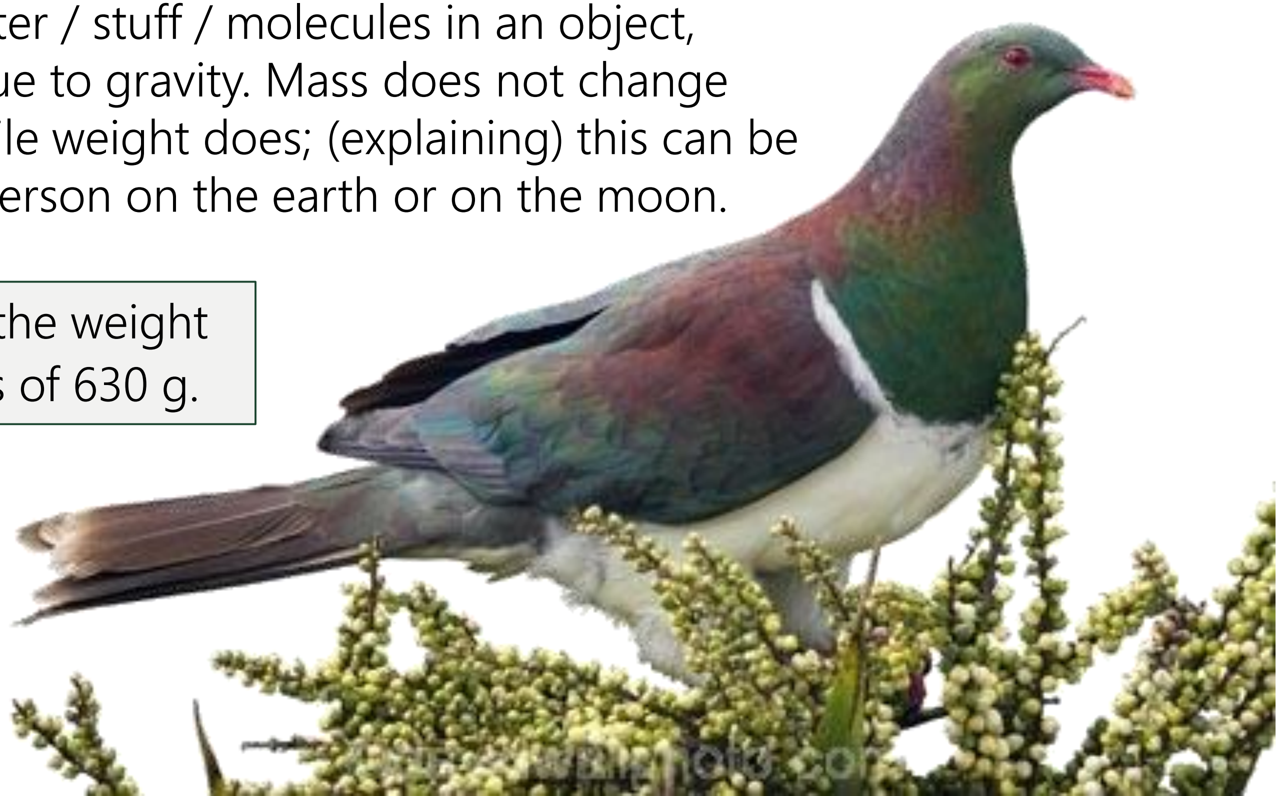
Question 2a(i) : The kererū (also known as New Zealand wood pigeon or kūkupa) is one of the largest pigeons in the world.
Explain the difference between mass and weight.

Answer 2a: Weight is the downward force due to gravity that an object experiences due to its mass, while mass is a measure of the amount of matter that an object has.
OR mass is amount of matter / stuff / molecules in an object, while weight is the force due to gravity. Mass does not change when location changes while weight does; (explaining) this can be given as an example of a person on the earth or on the moon.

Question 2a (ii): Calculate the weight of a kererū that has a mass of 630 g.

$$F_w = m \times g$$
$$= 0.630 \times 10$$
$$= 6.30 \text{ N}$$

Merit Question

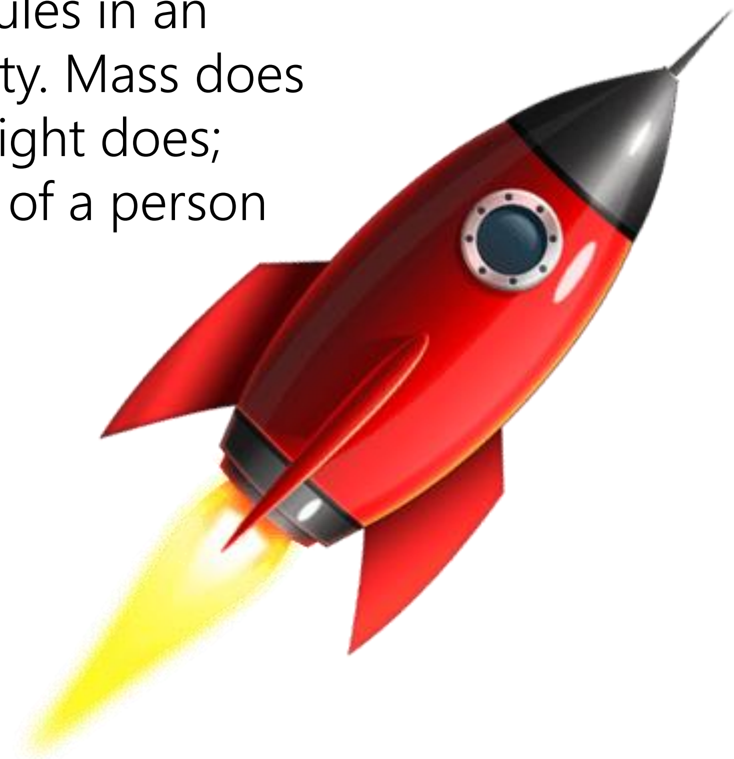


NCEA 2016 Mass and Weight - The Rocket

Merit Question

Question 3a: A small rocket has a mass of 2.60 kg and a weight of 26.0 N.
(a) Explain the difference between mass and weight.

Answer 3a: Weight is the downward force due to gravity that an object experiences due to its mass, while mass is a measure of the amount of matter that an object has.
OR mass is amount of matter / stuff / molecules in an object, while weight is the force due to gravity. Mass does not change when location changes while weight does; (explaining) this can be given as an example of a person on the earth or on the moon.



Merit Question

NCEA 2017 Mass and Weight – Waka Ama

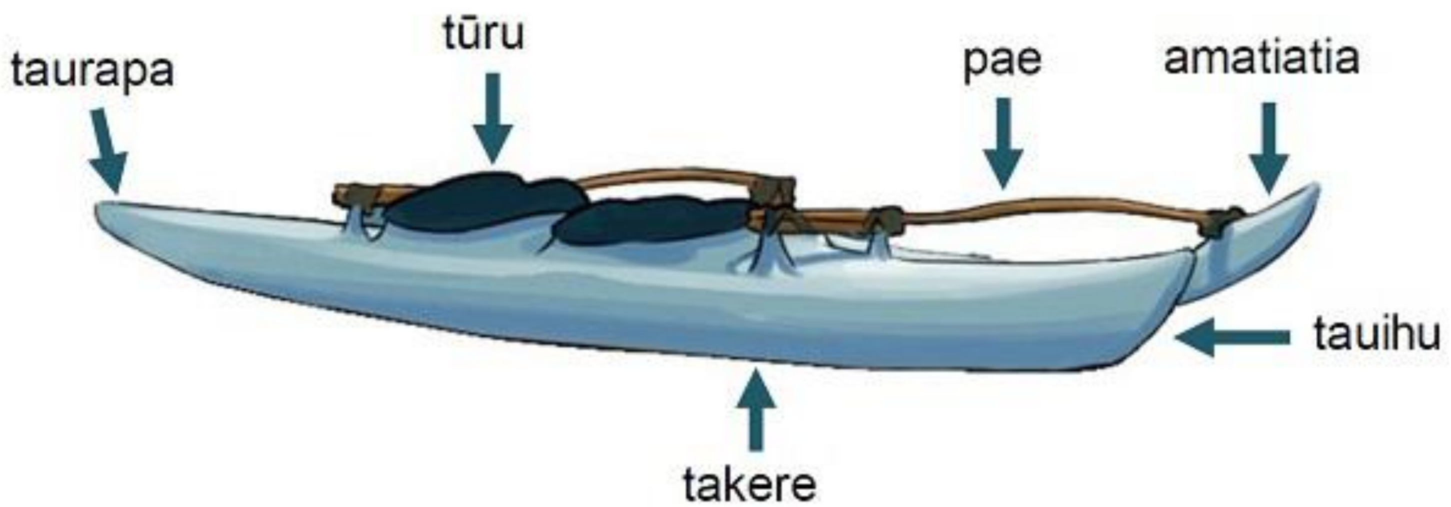
Question 2a: A lightweight waka ama (outrigger canoe) has a mass of 9.90 kg.
(a) What is the difference between **mass** and **weight**?
Use the waka ama as an example, and include a calculation for weight.

Weight is the downward force due to gravity that an object experiences due to its mass, while mass is a measure of the amount of matter that an object has.
(OR mass is amount of matter / stuff / molecules in an object, while weight is the force due to gravity) Mass does not change when location changes while weight does; this can be given as an example of a the waka ama that has a mass of 9.90kg but due to gravity (g = 10Nkg^{-1}) then the weight is

$F_w = m \times g$

$= 9.90 \times 10$

$= 99.0$ N



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Mass and Weight

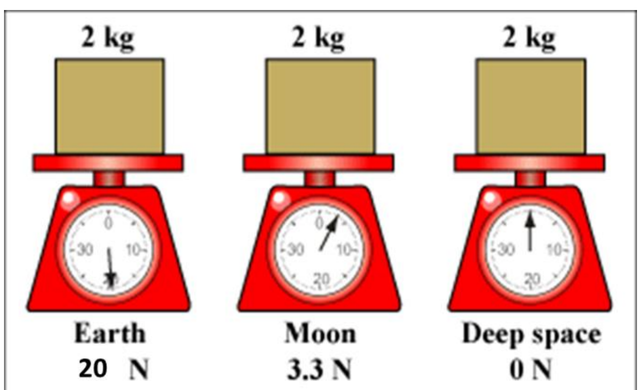
Question 2a(i) : The kererū (also known as New Zealand wood pigeon or kūkupa) is one of the largest pigeons in the world.
Explain the difference between mass and weight. Calculate the weight of a kererū that has a mass of 630 g.

Converting mass to weight

$F_w = mg$

g = acceleration due to gravity = ($10 ms^{-2}$)
Fw= Weight force (N)
m = mass (kg)

This is still the **F = ma** formula



How do we answer this question?

Weight is the downward force due to gravity that an object experiences due to its mass, while mass is a measure of the amount of matter that an object has.

Define and Compare Mass with Weight

Mass does not change when location changes while weight does; (explaining) this can be given as an example of a person on the earth or on the moon.

Explain Mass does not change but weight can

Mass is measured in kg while weight is a force measured in N

$$F_w = m \times g$$
$$= 0.630 \times 10$$
$$= 6.30 \text{ N}$$

Show working and remember units

GZ Science Resources

Units of Force, Motion and Energy in Science

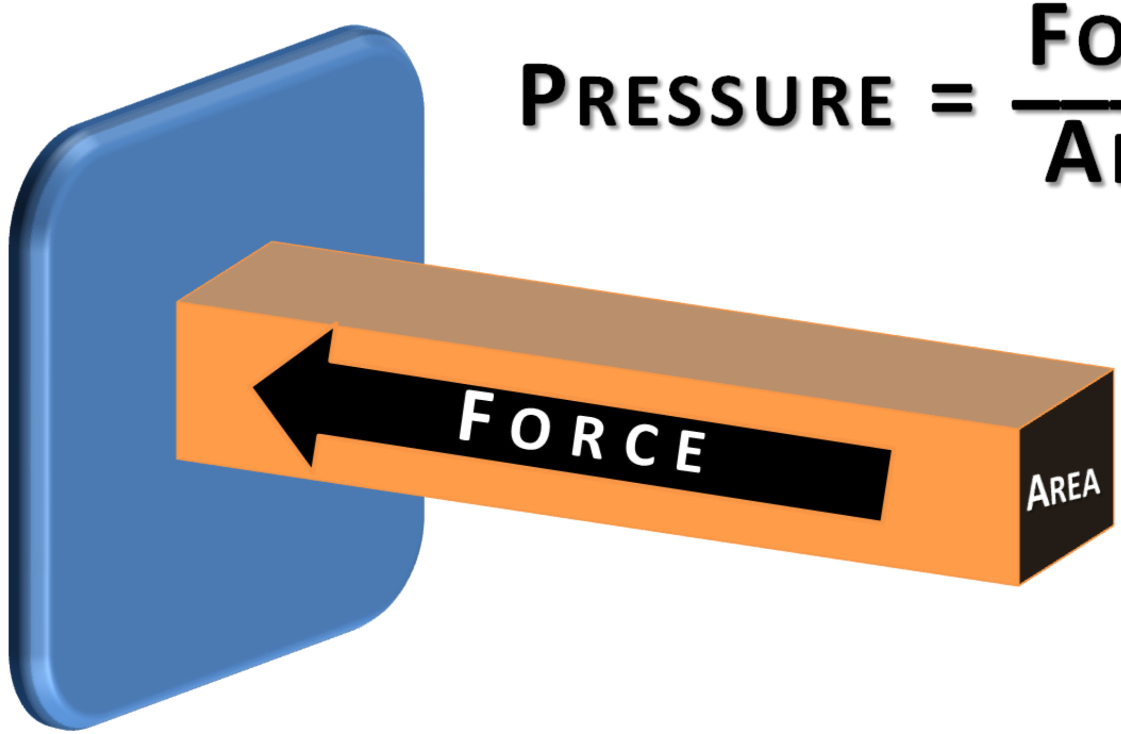
Quantity	Unit	Symbol	Equipment used
Force (weight)	Newton	N	Spring balance
Mass	Kilogram	kg	scales
Motion	Kilometres per hour (velocity)	khr^{-1}	odometer
	Metres per second (velocity)	ms^{-1}	Ticker timer
	Metres per second per second (acceleration)	ms^{-2}	Ticker timer
Energy (work)	Joule	J	
Power	Watt	W	

Remember: **These two units are shown as capitals**

Pressure

Pressure is a measure of force applied to a particular surface area. A *Pascal* is a pressure of one newton per square metre (Nm^{-2}) or using the units of Pascals (Pa).
Pressure is increased by increasing the force in the same surface area or reducing the surface area the force is applied to.

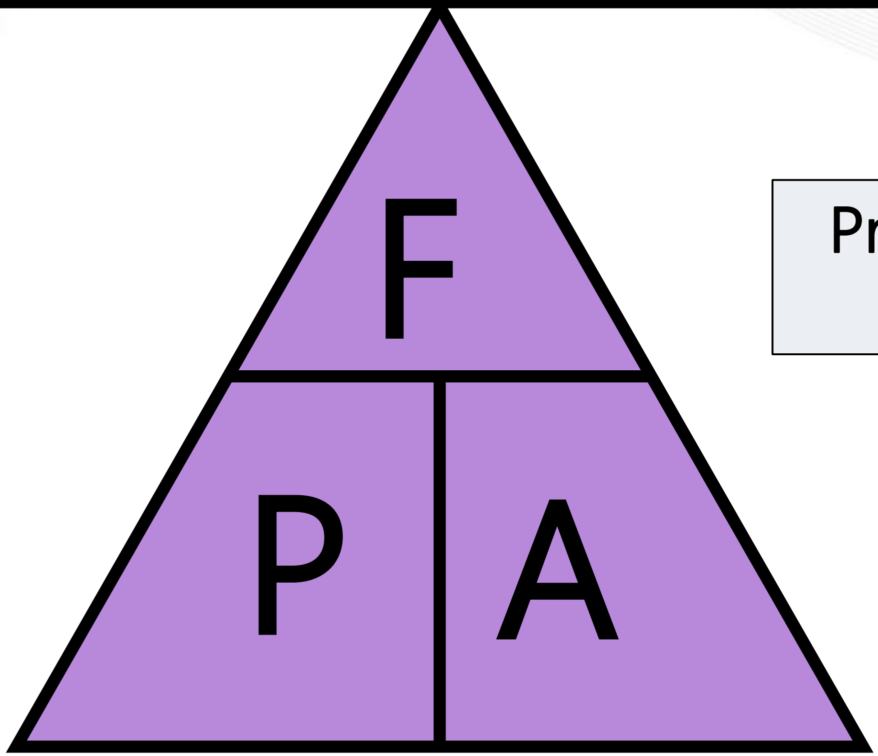
$$\text{PRESSURE} = \frac{\text{FORCE}}{\text{AREA}}$$



$$P = F/A$$

P = pressure(Nm^{-2})
F = force (N)
a = surface area (m^2)

Force is dependent on pressure and surface area it is exerted on



Pressure = Force / Surface Area

$P = F/A$

In many questions mass has to be converted into weight first.
Remember $F_w = mg$ where $g = 10ms^{-2}$

Area (surface) is expressed as m^2. If the surface area is given in cm^2 then this value must be divided by **10,000** to convert to m^2

Calculating Surface Area

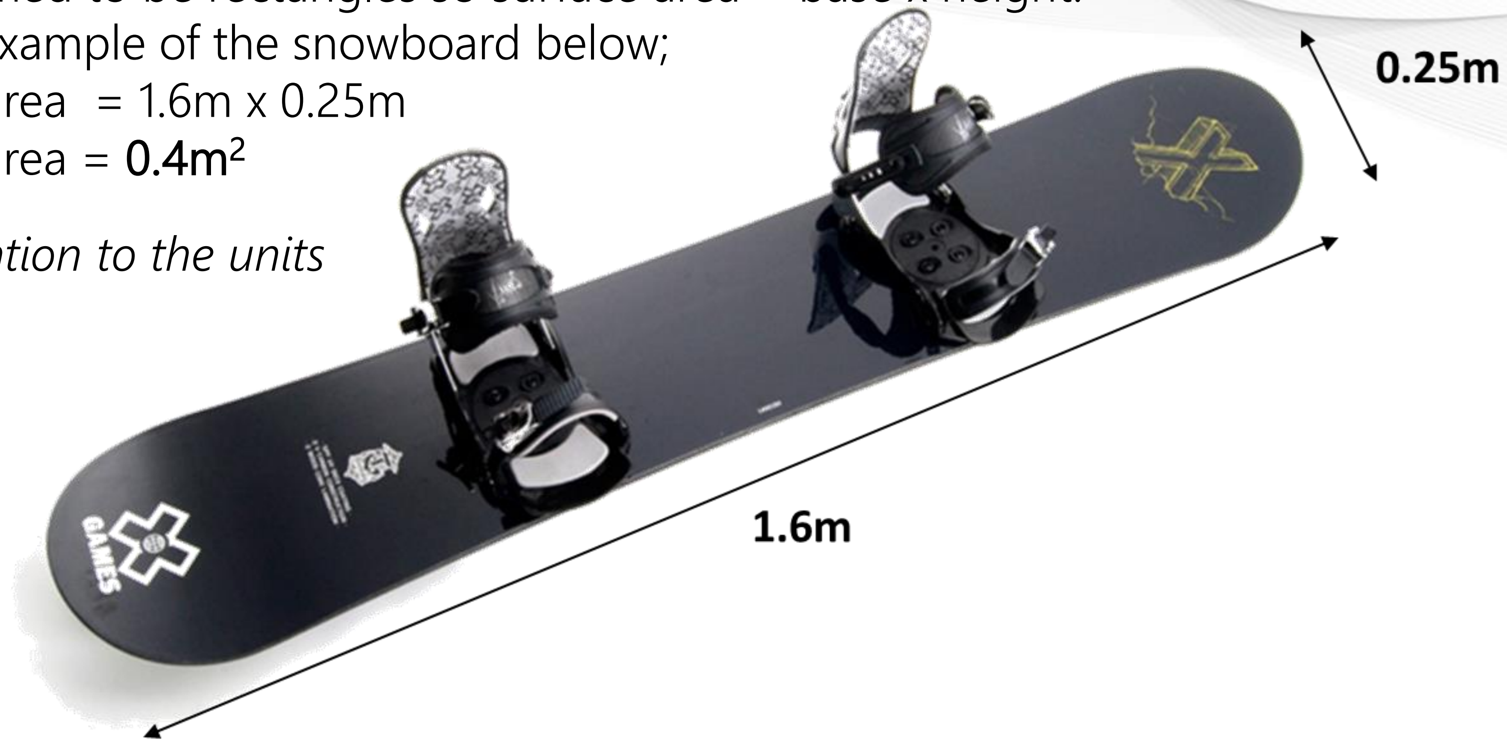
Surface Area is given in m^2. Sometimes this area must be calculated first. Objects are assumed to be rectangles so surface area = base x height.

For the example of the snowboard below;

Surface area = 1.6m x 0.25m

Surface area = **0.4m²**

Pay attention to the units



Because the value of P is in N m^{-2}, the surface area must be in **m^2**, not cm^2. If the base and height measurements are given in cm then to change cm to m, divide by 100;

If the surface area is given in cm^2 then to change cm^2 to m^2, divide by 100^2 (10 000)

Pressure in real life situations

Often the effects of pressure can be seen with **observation**.
For example, by how much an object presses into the surface it is sitting on. This could be skis into snow, tyres into mud or chair legs into carpet. The more the pressure, the deeper the imprints into the surface.

When comparing the pressure created by two different people of different masses sitting on the same object then the formula **P= F/A** must be used, discussing each variable.

Similarly, if two different people of different masses are on objects with different surface area, such as skis compared to a snowboard, the 'heaviest' person may not always create the most pressure if the surface area is large.

Remember to multiply surface area if 2 feet or 4 legs

NCEA 2012 Pressure - Car and Tractor tyres

Excellence Question

1d: While on the sandy beach the woman sees a car (m = 1100 kg) that is stuck in the sand. The photos below show the tread patterns of the tractor's rear tyre and the car's rear tyre. Compare the different treads of the tractor tyre AND car tyre in terms of force, surface area and pressure applied. Use this comparison to explain why the car gets stuck in the sand, BUT the tractor does not.

tractor tread

car tread

The car's tread pattern has a greater surface area in contact with the ground than the tractor.

The car's weight force ($F = mg$) will be less than the tractor's.

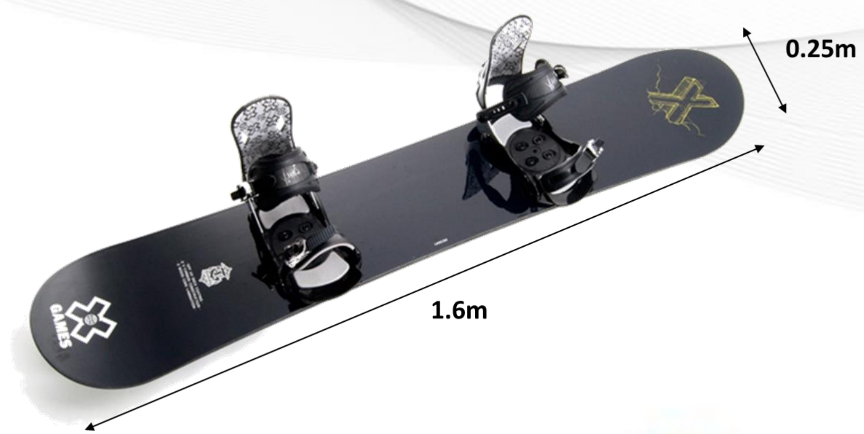
Since $P = F/A$, a smaller force divided by a larger surface area will lead to less pressure exerted on the ground than the tractor. Whereas the tractor having a larger force divided by a smaller area will apply far more pressure on the ground causing it to sink more.

On the beach grip / traction is achieved by sinking into the sand.

As the car applies a smaller amount of pressure on the sand it will not sink in therefore giving it less grip / traction and as a result it gets stuck in sand.

NCEA 2013 Pressure – Snowboard and skis

Q 4: A family decides to spend a day at a snow field. The father hires a snowboard for himself and a pair of skis for his daughter. Assume the snowboard and skis are **rectangular** in shape.
The father and snowboard have a combined mass of 80 kg.
(a) Calculate the pressure exerted by the father and snowboard on the snow.
Your answer should include:
- an area calculation
- a calculation of the pressure.



$F_{weight/gravity} = mg = 80 \times 10 = 800$ N

Area $= b \times h = 0.25 \times 1.6 = 0.4$ m^2

$P = F / A = 800 / 0.4 = 2\,000$ Pa (Nm

Don't forget units

NCEA 2013 Pressure– Snowboard and skis (part 2)

Q 4b: The father notices that his daughter on her skis has sunk further into the snow than he has on his snowboard. The father and snowboard have a combined mass of 80 kg. The daughter and the skis have a combined mass of 58 kg. Explain why the daughter on her skis sinks further into the snow than her father on his snowboard.

In your answer you should:

- calculate the pressure exerted by the daughter and her skis on the snow
- compare the pressure exerted by the daughter and father (from part (a)) on the snow
- explain the difference in pressure in terms of force AND area
- explain how pressure relates to how far the person will sink in the snow.

Sinking depends on pressure – the greater the pressure, the further the person sinks.

$P = F/A$

A 'lighter' person will have less weight force than a 'heavier' person. However, if the 'lighter' person's force is spread over a smaller surface area, it can produce a higher pressure than the 'heavier' person.

In this example, the skis have much less surface area than the snowboard, so the daughter sinks further than her father, even though she is 'lighter'.

$P_{dad} = 800/0.4 = 2\ 000$ Pa

$F_{daughter} = 58 \times 10 = 580$ N $A_{daughter} = 2 \times 0.08 \times 1.75 = 0.28$ m^2

$P_{daughter} = F / A = 580 / 0.28 = 2071$ Pa

$P_{daughter} > P_{dad}$ so daughter sinks further into the snow.

Remember to double area if 2 feet or boots

2014 NCEA Pressure – Chairs and footstools

2b: The footstool was pushed around the house.
Select the correct statement below and then explain your choice.
A. It is easier to push the footstool across carpet than across a wooden floor.
B. It is easier to push the footstool across a wooden floor than across carpet.
Write the letter of the correct statement:
Explain why you have selected this statement.

Statement B
There is less friction on the wooden floor, so it takes less force to push the footstool on this surface.
OR
There is more friction on carpet so it takes more force to push the footstool on this surface.

2014 NCEA Pressure – Chairs and footstools

2c: The chair (15.0 kg) has four legs in contact with the floor, whereas the base of the footstool (15.0 kg) does not have legs and is entirely in contact with the floor. The area of each chair leg in contact with the floor is 0.001 m^2.
Calculate the pressure that the chair (mass 15.0 kg) exerts on the carpet.
In your answer you must determine:
- the area of the chair legs in contact with the floor
- the weight force of the chair
- the pressure acting on the carpet.

Surface area of the chair legs:
$4 \times 0.001 = 0.004$ m^2
Weight of chair:
$Fw = m \times g = 15 \times 10 = 150$ N
Pressure exerted:
$P = F/A = 150 / 0.004 = 37\,500$ Pa (Nm^{-2})

Area must be in m^2

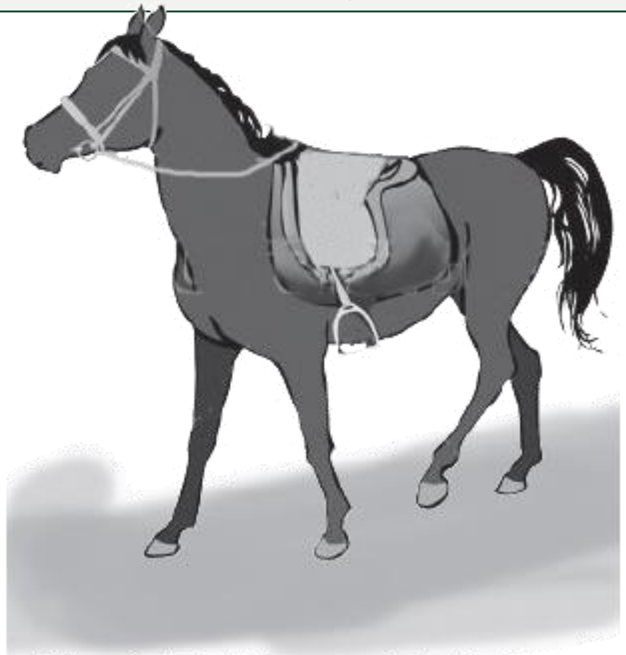
2d: A person sat on the chair and then sat on the footstool for the same period of time. They noticed that the chair legs left deeper marks in the carpet than the footstool did, although both the chair and footstool have the same mass.
Explain these differences in terms of pressure, force, and surface area.

The footstool has a **much larger surface area** in contact with the floor than the chair.
The **force applied to both** the chair and the footstool **are the same** because the same person sits on both.
$P = F / A$, so **if *Area* is bigger then the pressure must be smaller** (or vice versa).

Include formula in explanation

NCEA 2016 Pressure - The Horse

Q1c Each of the horse's hooves has a surface area of 44 cm2 (0.0044 m2) and sinks into the sand when the horse stops. The hooves exert a pressure of 200155 Pa.
Calculate the weight of the horse.



F = P x A
F = 200155 Pa x (0.0044 x 4)
F = 200155 Pa x 0.0176 m^2
F = 3522.7 N

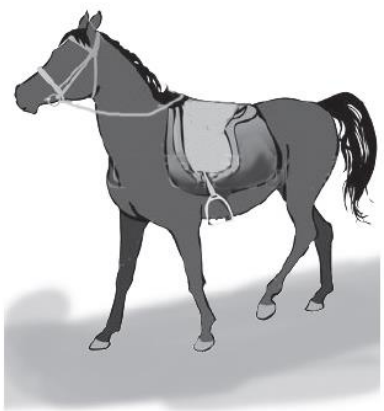
Force is the weight exerted by the horse

This question requires you to work backwards from pressure.
Calculate F (weight) by F = P x A and remember to multiply area by 4 hooves

NCEA 2016 Pressure - The Horse (part 2)

Excellence Question

1d. The rider walks beside the horse and then gets onto the horse. Explain why the horse's hooves sink further into the sand when the rider gets onto the horse. In your answer you should consider the **pressure applied** and the **forces acting**. (No calculations are necessary.)



The horse with or without the rider has the same surface area in contact with the ground.

With the horse by itself, the weight force ($F = mg$) will be less than the horse with a rider.

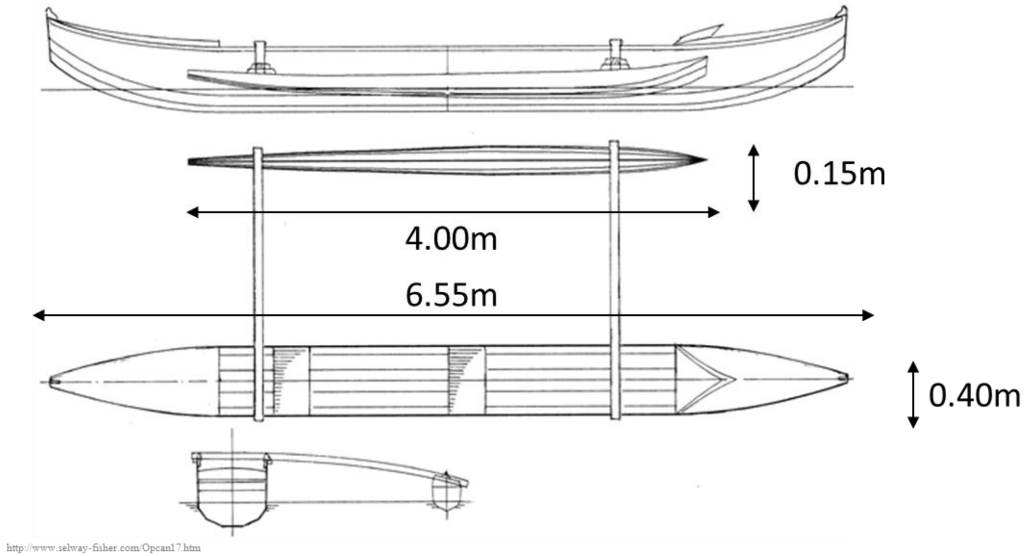
Since $P = F/A$, a smaller force (horse only) divided by the surface area will lead to less pressure exerted on the ground than the horse with rider. Whereas the horse with rider having a larger force divided by the same surface area will apply far more pressure on the ground causing it to sink more.

As the horse by itself applies a smaller amount of weight (and therefore pressure) on the sand it will not sink in as deep.

NCEA 2017 Pressure – Waka Ama (part ONE)

Excellence Question

Question 2b: A sketch of the waka ama hulls is shown below right.
(b) Calculate the pressure exerted by the waka ama (both hulls) on the water.
Your answer should include:
• an area calculation (assume both waka ama hulls are rectangular in shape, and the measurements above show the area in contact with the water)
• a calculation of the pressure. (A lightweight waka ama has a mass of 9.90 kg.)



Surface area of the waka ama large hull:
6.55m × 0.40m = 2.62 m^2
Weight of waka ama hull :
$Fw = m \times g$ = 9.90 × 10 = 99.0 N
Pressure exerted of the waka ama (both) hull :
$P = F/A$ = 99.0 / 3.22 m^2
= 30.7 Pa (Nm^{-2})

Surface area of the waka ama small hull:
4.00m × 0.15m = 0.60 m^2
Total surface area of BOTH hulls:
=2.62 m^2 + 0.60 m^2 = 3.22 m^2

Excellence Question

NCEA 2017 Pressure – Waka Ama (Part TWO)

Question 2c: The waka ama sinks further into the water when a 67 kg paddler sits in it.
Explain why the waka ama sinks further into the water when the paddler sits in it.
Use calculations to support your answer.

Sinking depends on pressure – the greater the pressure, the further the waka ama sinks. $P = F/A$

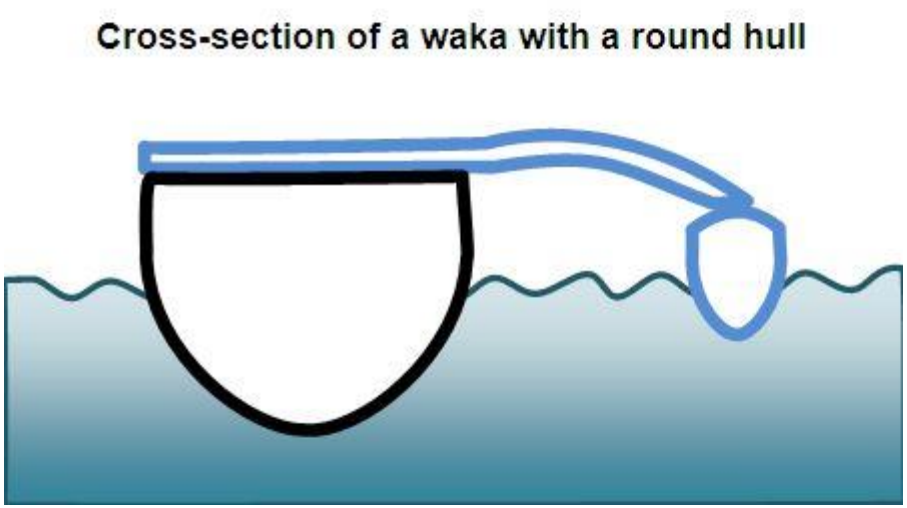
A 'heavier' waka ama (with the person in) will have more weight force than a 'lighter' person. The weight in total after will be F_w (total) = $m \times g = 76.9 \times 10 = 769$ N

$P = F/A = 769 / 3.22\ \text{m}^2 = 238.8(\text{Nm}^{-2})$

Sinking into the water depends on pressure – the greater the pressure, the further the waka ama sinks. $P = F/A$

A 'lighter' waka ama will have less weight force than a 'heavier' waka ama.

In this example, the waka ama has the same area but a greater weight when the paddler is in the canoe, so the waka ama sinks deeper into the water because the pressure has increased.



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Excellence Question

NCEA 2018 Pressure – Running Race

Question 1d: Each of Runner A's feet has a surface area of 200 cm^2 (0.0200 m^2), which sink into the track. Together, the feet exert a pressure of 13 000 Pa.
Calculate the **weight** of Runner A.

Surface area of both feet
$= 2 \times 0.0200$
$= 0.0400 \text{ m}^2$
$F = P \times A$
$= 13000 \times 0.0400$
$= 520$ N (2 sf)
(Correct significant figures not required.)

Excellence Question

NCEA 2018 Pressure – Skiing

Question 3d : Jake changes to his wide skis. The skis measure 10 cm in width compared with normal skis of 5 cm. Both sets of skis are the same length.
Explain why Jake does not sink into the snow as much when he uses his wide skis.
Calculations are not required.

Freepik.com

Sinking into the snow depends on pressure – the greater the pressure, the further the skis sink in to the snow.

$P = F / A$

The weight force does not change, but the surface area does. If the surface area is increased, then the pressure exerted on the snow is decreased. A larger surface area with the same weight will have less pressure than a smaller surface area with the same weight.

Merit Question

NCEA 2019 Pressure – Walking in sand

Question 2a : An adult and a child's feet sink into soft sand. The footprints are the same depth. The child's footprints cover a smaller area than the adult's.
Pressure is defined as the force exerted divided by the surface contact area.
Using this pressure definition, explain how it applies to the adult standing in the sand.

The adult has a weight force that is acting down on the sand through their feet. Pressure is created as the adult's weight is spread over the surface area of their feet.

(2b) The surface area of one of the adult's footprints is 200 cm^2 (0.0200 m^2), and the surface area of one of the child's footprints is 150 cm^2 (0.0150 m^2). The adult has a weight of 690 N.
Show the total pressure the adult exerts on the sand is 17 250 Pa.

$A = 0.020 \times 2 = 0.040\ m^2$

$P = F/A = 690/0.04 = 17\ 250\ Pa$

Excellence Question

NCEA 2019 Pressure – Walking in sand

Question 2c : Explain how the footprints are the same depth, although the mass of the child is smaller.
In your answer include a discussion of pressure, surface area, and mass.

(d) Both the adult's and the child's footprints are the same depth.
Calculate the mass of the child.

Pressure equals the force exerted divided by the surface (contact) area, The child has the same pressure as the adult because they sink an equal distance into the soft sand. However, the child has a smaller surface (contact) area on the sand, and thus must exert a smaller force for the pressure to remain the same. The smaller force is the gravitational force, which means that the mass of the child must be smaller as $F_g = mg$.

$A = 0.015 \times 2 \quad = 0.030 m^2$

$F = PA = 17250 \times 0.03$

$F = 517.5 N$

$m = F/g = 517.5 / 10$

$m = 51.8 kg$

Pressure

Q 2: The father notices that his daughter on her skis has sunk further into the snow than he has on his snowboard. The father and snowboard have a combined mass of 80 kg. The daughter and the skis have a combined mass of 58 kg. Explain why the daughter on her skis sinks further into the snow than her father on his snowboard.

In your answer you should:

- calculate the pressure exerted by the daughter and her skis on the snow
- compare the pressure exerted by the daughter and father (from part (a)) on the snow
- explain the difference in pressure in terms of force AND area
- explain how pressure relates to how far the person will sink in the snow.

$F_{weight/gravity} = mg = 80 \times 10 = 800$ N

Area = $b \times h = 0.25 \times 1.6 = 0.4$ m^2

$P = F / A = 800 / 0.4 = 2\,000$ Pa (Nm^{-2})

P=F/A

P = pressure(Nm^{-2})
F = force (N)
a = area (m^2)

How do we answer this question?

Sinking depends on pressure – the greater the pressure, the further the person sinks. $P = F/A$

Explain sinking/traction is due to pressure

A 'lighter' person will have less weight force than a 'heavier' person. However, if the 'lighter' person's force is spread over a smaller surface area, it can produce a higher pressure than the 'heavier' person.

Link pressure to both weight force and surface area

In this example, the skis have much less surface area than the snowboard, so the daughter sinks further than her father, even though she is 'lighter'.

Link pressure to example with comparison

$P_{dad} = 800/0.4 = 2\,000$ Pa

$F_{daughter} = 58 \times 10 = 580$ N $A_{daughter} = 2 \times 0.08 \times 1.75 = 0.28$ m^2

$P_{daughter} = F / A = 580 / 0.28 = 2071$ Pa

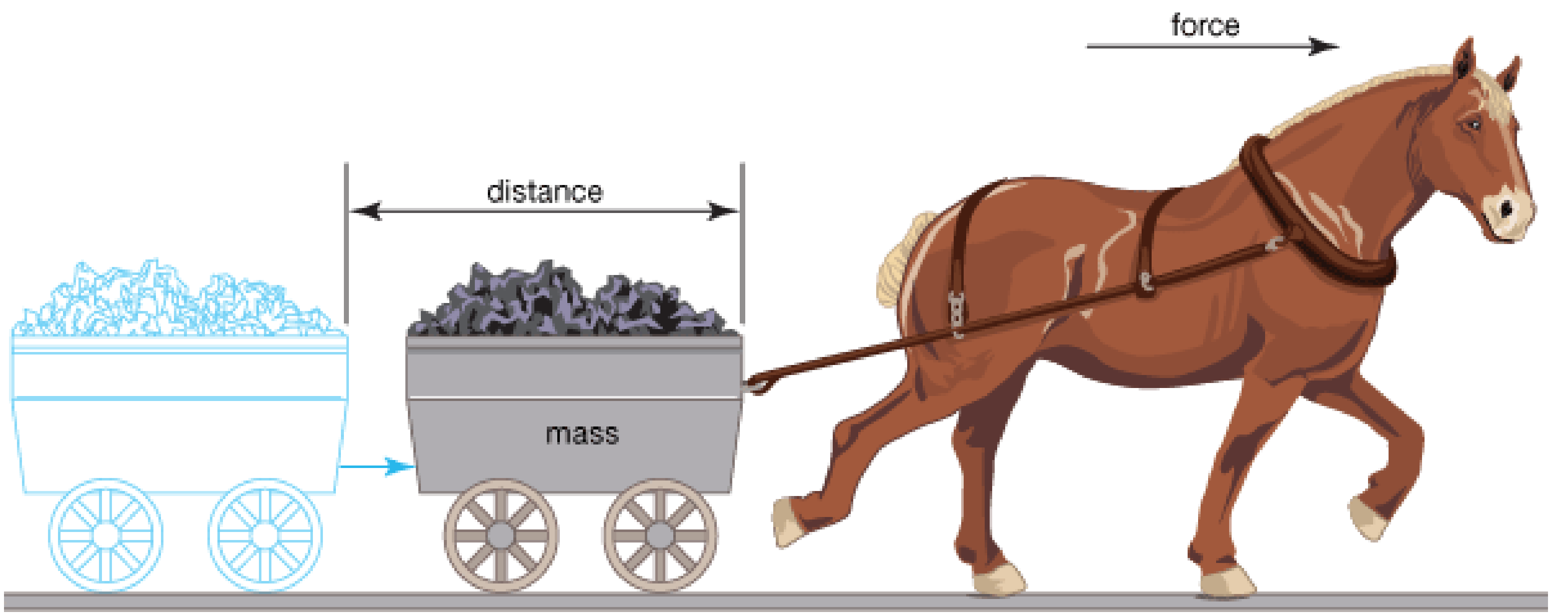
$P_{daughter} > P_{dad}$ so daughter sinks further into the snow.

Use calculations to back up statement

Work

When a force is applied to an object of mass and moves it over a distance then **work** has been done. If an object does not move, no matter how much force is applied, then no work has been done.
Work is proportional to the force applied (weight force) and the distance travelled so *Work = Force × distance*. Work is needed to transfer energy.

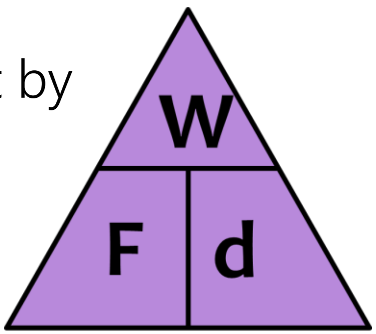
*Work is measured in **joules**.*
To do 1 joule of work you need 1 joule of energy.



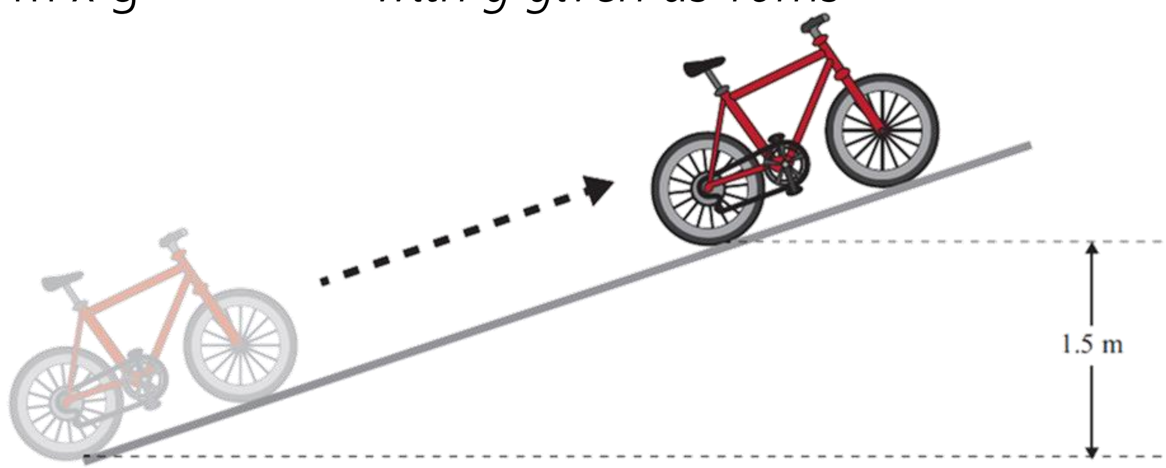
Calculating Work

Force in a work calculation, is often refers to Weight force *(F_w)*
*Remember **weight** is the downward force due to gravity that an object experiences due to its mass.*

If mass is given then weight will need to be calculated first by



$F_w = m \times g$ *with g given as $10ms^{-2}$*



$$W = Fd$$

W = work done (J)
F = force (N)
d = distance (m)

If the force is due to weight force then the distance moved if travelling up a ramp will be the **vertical distance**. In the situation above the distance is 1.5m NOT the length of the ramp.

Power

Power is a measure of work done over time. Power is measured in units called **watts (W)**. A watt is one joule per second

Power is also the rate at which energy is transformed, (such as electrical energy in a bulb to light and heat energy - which is the same thing as the rate at which work is done.

- A 100 Watt light bulb is able to do a large amount of work (energy) in a period of time.
- A 40 Watt bulb will do less work (energy) in the same amount of time.

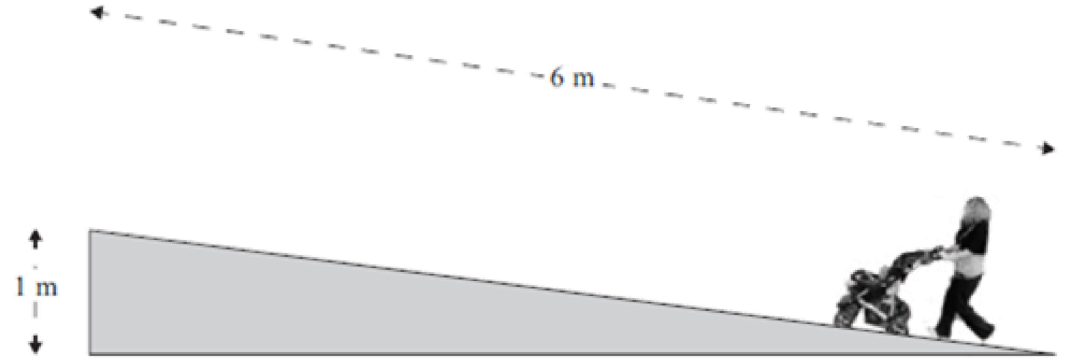
100 watts means 100 J s^{-1}

Ramps and Power

A ramp is a sloping surface that masses can be lifted to a height. Generally speaking, it will take a longer time to lift a mass up a ramp than lifting directly up to the same height. The ramp is a 'simple machine'.
If the same amount of work is done, for example a box of the same mass is either lifted directly upwards compared to a box wheeled up a ramp to the same height BUT lifting straight upwards takes less time – then more power is used to lift the box straight up.
Ramps make moving masses 'easier' as allows the same amount of work to be done with a smaller force over a greater distance. In addition, ramps require less power to be used for the same weight (force) if it takes longer to reach the same height.

$$P = W/t$$

W = work done (J)
P = power (W)
t = time (s)



Calculating Power

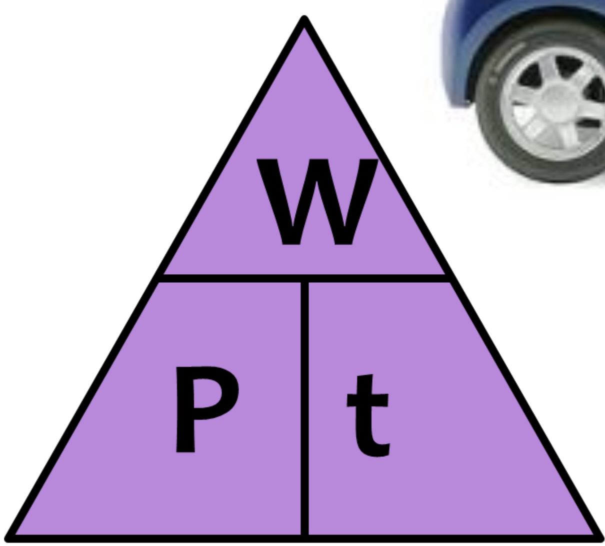
Calculating power is normally completed in three steps:

1. calculate the weight (force) of the object with units $F_w = m \times g$
2. calculate the work done by the object with units $W = F \times d$
3. calculate the power required to lift the object with units $P = W / t$

Force = 20N

Time = 25seconds

Distance = 5 metres

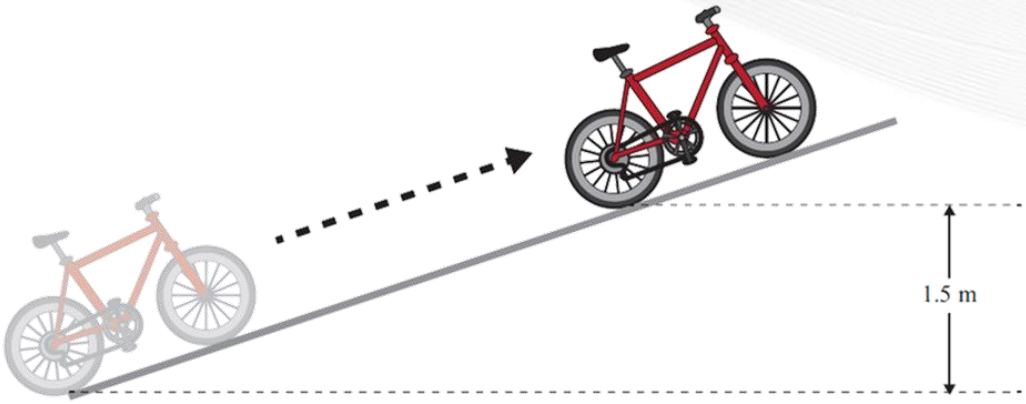


A car is pushed with a force of 20N and travels 5 metres.
The work done is W= f x d w = 20 x 5 = 100 joules
The power used to push the car is p = W/t p = 100/25 = 4 Watts

Work, power and Ramps

Why does pushing an object up a ramp seem easier than lifting it straight upwards?

The same work is required overall but going up the ramp, the push force required is against a only a component of the gravity force of the bike. However, a vertical lift would require a push equal to gravity force. Therefore the force required to lift the bike straight up is greater than the force required to push it up the ramp. The distance pushing straight upwards is shorter compared to the ramp though.



The same work is done in both cases but because the ramp spreads the work out over a longer time it seems "easier"

The energy gained by the bike is the same in both cases, but the time taken to go up the ramp is greater than lifting it vertically. As $P = W / t$, a greater time would mean **less power is required**.

Work and Power

Q3c: A forklift lifts the box 4 metres straight up so it can be placed on a shelf. It takes 5 seconds to lift the box at a constant rate.
Calculate the work done to lift the box to the height of 4 m, and then calculate the power needed by the forklift to lift it to this height. .

Why does pushing an object up a ramp seem easier than lifting it straight upwards?

W=Fd

W = work done (J)
f = force (N)
d = distance (m)

P=W/t

W = work done (J)
P = power (W)
t = time (s)

How do we answer this question?

$F = 25\,000$ N

$W = Fd = 25\,000 \times 4 = 100\,000$ J

$P = W / t = 100\,000 / 5 = 20\,000$ W

Show working and use correct units

How do we answer this question?

The same work is required overall but going up the ramp, the push force required is only against a component of the gravity force of the bike. However, a vertical lift would require a push equal to gravity force. Therefore the force required to lift the bike straight up is greater than the force required to push it up the ramp. The distance pushing straight upwards is shorter compared to the ramp though.

Compare both Force and Distance of both

The energy gained by the bike is the same in both cases, but the time taken to go up the ramp is greater than lifting it vertically. As $P = W / t$, a greater time would mean **less power is required**.

Link power to time taken

NCEA 2013 Work and power - the forklift

Q3: A box in a warehouse has a mass of 2 500 kg.
(a) Explain the difference between weight and mass.
(b) Calculate the weight of the box.

Weight is the downward force due to gravity that an object experiences, while mass is a measure of the amount of matter that an object has.

$F_{weight/gravity} = mg = 2\ 500 \times 10 = 25\ 000$ N

Q3c: A forklift lifts the box 4 metres straight up so it can be placed on a shelf. It takes 5 seconds to lift the box at a constant rate. Calculate the work done to lift the box to the height of 4 m, and then calculate the power needed by the forklift to lift it to this height.

Excellence Question

$F = 25\ 000$ N

$W = Fd = 25\ 000 \times 4 = 100\ 000$ J

$P = W / t = 100\ 000 / 5 = 20\ 000$ W

NCEA 2013 Work and power - the forklift (part 2)

Excellence Question

Q3: (d) Find the **average speed** of the box as it moves up to the 4 m high shelf.
(e) Explain how the power needed to lift the box would be affected if the box was lifted at twice the speed.
In your answer you should consider how increased speed affects the time taken.

$v = d / t = 4 / 5 = 0.8 \text{ m s}^{-1}$

The power needed will increase. This is because if the speed is doubled, the time to lift the load is halved.

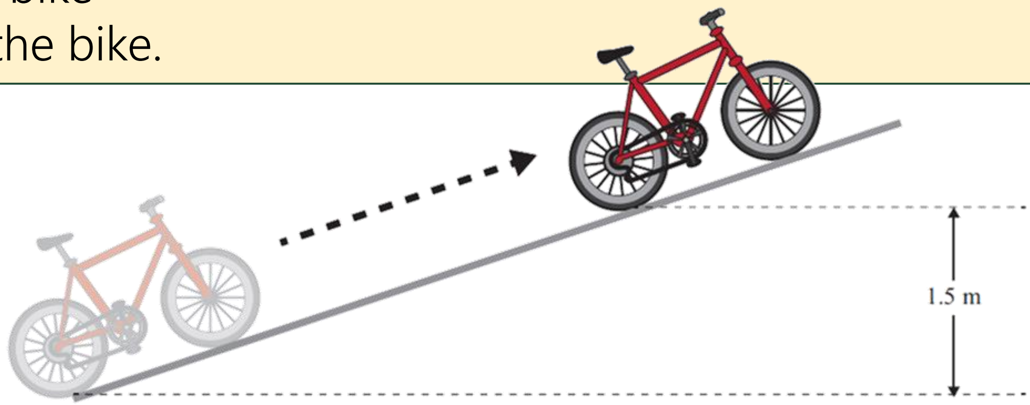
Since the work done does not change and power is a measure of the amount of work done per second, if the time is halved the power is doubled.

Link increased speed to decreased time to lift the box. Then clearly show the **link between time and power** when explaining why power has increased. (This could be done either stating the equation $P = W / t$ or describing that relationship through words).

2014 NCEA Work and power – the bike

1c: A bike with a mass of 20 kg is lifted onto a shelf that is 1.5 metres high. It takes 3 seconds to lift the bike. Calculate the power required to lift the bike onto the shelf.
Before you calculate the power, you will need to:
- determine the weight force of the bike
- calculate the work done in lifting the bike.

$F = 20 \times 10 = 200$ N
$W = F \times d = 200 \times 1.5 = 300$ J
$P = W / t = 300 / 3 = 100$ W



1d: A person pushed the same bike up a ramp that it was also at a height of 1.5m. It then took them a longer time to do this than lifting the bike. Explain whether the power needed to push the bike up the ramp is more or less than when it is lifted straight up to the same height. Refer to force and energy.

As the height above the ground is the same, **the same work is required** to travel up the ramp as lifting the bike straight up. If the same amount of work is done, the same amount of energy is gained. As $W = F \times d$, if d is increased, the amount of force required to do the same amount of work will be less, ie a ramp allows the same amount of work to be done with a smaller force over a greater distance.

NCEA 2014 Work – Construction

Achieved Question

Question 3a: During the construction of a building, a long beam was lifted into place using a crane.
Calculate the work done in lifting the beam with a weight of 6000 N through a distance of 50 m.

$W = F \times d = 6\,000 \times 50 = 300\,000$ J

Merit Question

Question 3b: Explain why there is no work being done when the beam is hanging in the air without moving.

Work is done when a force causes the beam to move in a direction of the force. The force is not causing the object to move, so no work is being done.

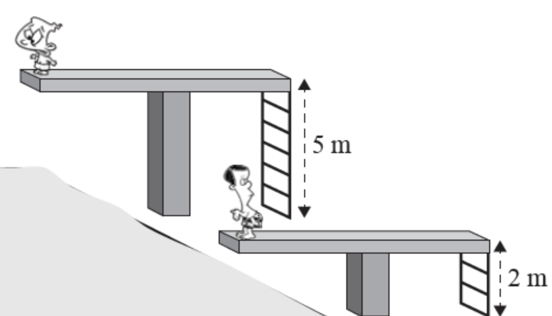
(No distance travelled in the direction of the force)

NCEA 2015 Work - Diving

Question 1b: How much work did Chris (48 kg) do when he climbed up the stairs to the 2 m platform?

Merit Question

$F = m \times g$
$= 48 \times 10$
$= 480$ N
$W = F \times d$
$= 480 \times 2$
$= 960$ J
OR
$E_p = mgh$
$= 48 \times 10 \times 2$
$= 960$ J



Question 1c: Ian's mass is 52 kg.
Why did Ian do more work climbing up the 5 m ladder compared to Chris climbing up the 2 m ladder?

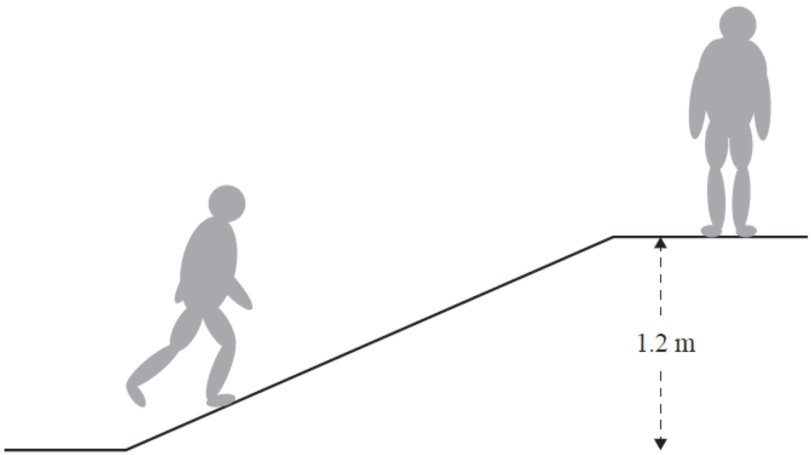
Merit Question

Answer 1c: Work is proportional to the force applied (weight force) and the distance travelled.
OR $W = F \times d$ (formula or words)
OR work is needed to transfer energy, as Ian has more mass and weight, he also climbs longer distance, more energy transferred therefore more work done.
Ian completes a greater amount of work because he had a mass of
52 kg, compared with Chris with a mass of 48 kg
Ian climbs a greater distance, 5 m, compared with Chris, who climbed only 2 m

NCEA 2016 Work and Power - The Combine Harvester

Excellence Question

2c. The harvested grain is stored in a shed with a ramp.
(An 85 kg worker climbed to the top of the ramp, a height of 1.2 m. This took 8 seconds. Calculate the **work** done by the worker to get to the top of the ramp and therefore the **power** exerted. Include units.



F = 85 kg x 10 = 850 N

$W = Fd$ = 850 N × 1.2 m = 1020 J

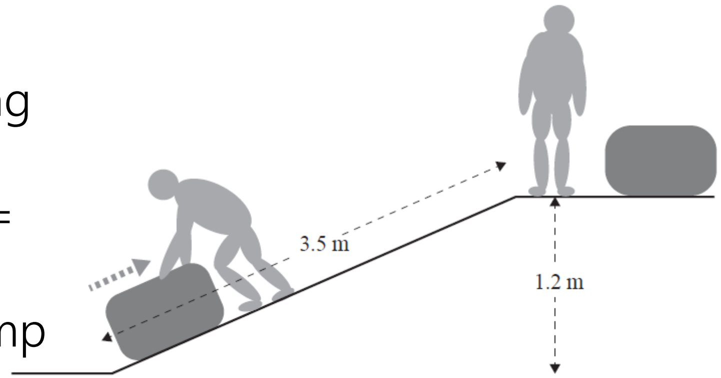
$P = W / t$ = 1020 J / 8 s = 127.5 W

NCEA 2016 Work and Power - The Combine Harvester (part 2)

Excellence Question

2d. The worker dragged a 25 kg bag of grain up the 3.5 m ramp to reach the height of 1.2 m. It took longer to drag the bag up the ramp than to lift the bag straight up to the top of the ramp.
(i) Explain why the **force** needed to drag the bag of grain up the ramp to the top is less than the force needed to lift the bag straight up (vertically). Ignore friction.

As the height above the ground is the same, **the same work is required** to travel up the ramp as lifting the bike straight up. If the same amount of work is done, the same amount of energy is gained. As $W = F \times d$, if d is increased, the **amount of force required to do the same amount of work will be less**, ie a ramp allows the same amount of work to be done with a smaller force over a greater distance.



(ii) Explain whether the **power** needed to drag the bag of grain to the top of the ramp is more or less than the power needed when the bag is lifted straight up (vertically) to the top of the ramp.
(No calculation is required.)

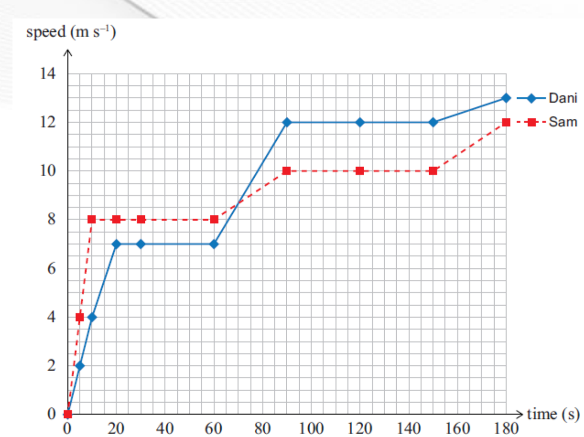
The energy gained by the bag of grain is the same in both cases, but the time taken to go up the ramp is greater than lifting it vertically. As $P = W / t$, a greater time would mean **less power is required**.

Merit Question

NCEA 2017 Work – horse racing

Question 1b: Sam's horse accelerates for the first 10 s of the race AND covers a distance of 40 m. Sam and his horse have a total mass 308 kg.

(b) Use the acceleration to calculate the work that Sam and his horse have done in the first 40 m.



$a = \Delta v / \Delta t$

$= \frac{8 - 0}{10 - 0}$

$= 0.8 \text{ ms}^{-2}$

$F_w = m \times a$

$= 308 \times 0.8 \text{ ms}^{-2}$

$= 246.4 \text{ N}$

$W = F \times d$

$= 246.4 \times 40 =$ **9856J (9.86 kJ)**

https://www.cnet.com/news/horse-racing-genetics-training-kentucky-derby-improve-the-odds/

Excellence Question

NCEA 2017 Work and Power – horse racing

Question 1c: Explain the effect on **work** AND **power** if a new, heavier jockey was on Sam's horse, which had the same speed and acceleration over the race.
Calculations are not required.

Work is proportional to the force applied (weight force) and the distance travelled.
OR $W = F \times d$ (formula or words)
Work is needed to transfer energy, if there is a heavier jockey there will be more mass and therefore more weight force, more energy transferred therefore more work done. The horse and the heavier jockey completes a greater amount of work than a lighter jockey.

The energy (Work) used by the heavier jockey is greater, but the time taken to cover the same distance is the same as the speed and acceleration is the same. As $P = W / t$ *and* $W = P \times t$, a greater weight would mean **more power is required** if more work is done in the same time.

https://www.thesun.co.uk/sport/horseracing/4499030/sandown-yarmouth-beverley-kelso-steve-mullen-horse-racing-tips/

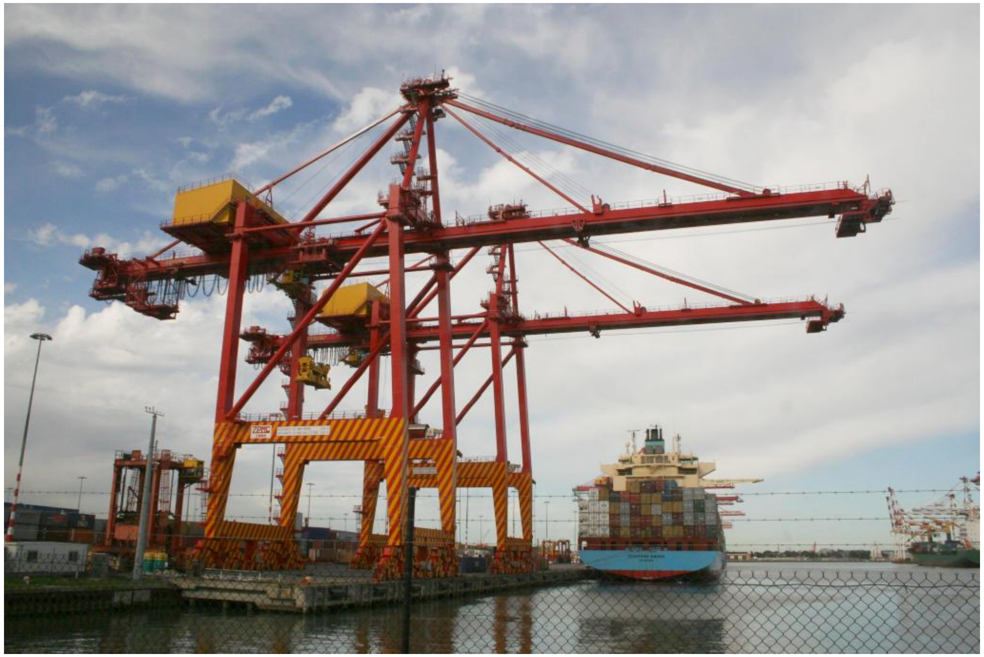
Merit Question

NCEA 2017 Work and Power – The Crane (Part ONE)

Question 3a: The crane shown below lifted a container 30 m in 15 s. The weight of the container is 60 000 N.
(i) Calculate the work done by the crane in lifting the container 30 m.

$F = 60\ 000$ N

$W = Fd = 60\ 000 \times 30$
= 1 800 000 J
= 1800 kJ



Question 3a: (ii) Calculate the power of the crane while lifting the container 30 m in 15 s.

$P = W / t = 1\ 800\ 000$ J / 15 s
= 120 000 W or 120kW

https://commons.wikimedia.org/wiki/File:Melbourne--swanston-dock-container-crane.jpg

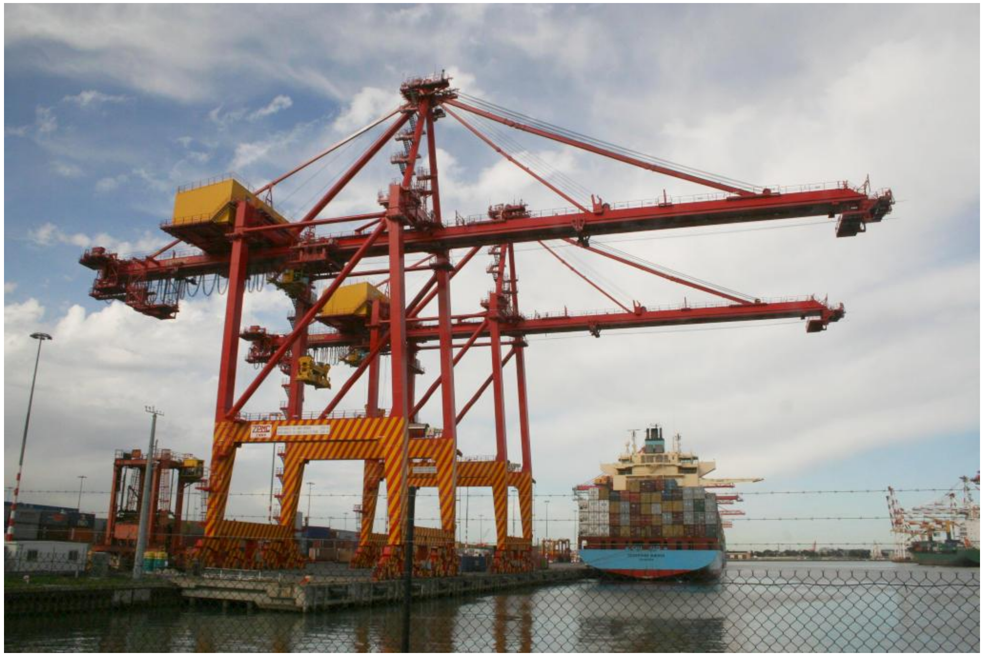
Merit Question

NCEA 2017 Work and Power – The Crane (Part TWO)

Question 3b: Explain what work is being done on the container when it is hanging in the air without moving.

Work is done when a force causes the container (load) to move in a direction of the force. The force is not causing the object to move, so no work is being done.

(No distance travelled in the direction of the force)



https://commons.wikimedia.org/wiki/File:Melbourne--swanston-dock-container-crane.jpg

Excellence Question

NCEA 2018 Work and Power – Mountain biking

Question 2c : Willow had to choose between two ramps to ride her bike to the top of an incline. It takes less time to use Ramp B.
Is the **work** needed to get to the top of **Ramp A** more, less, or the same as the work needed to get to the top of Ramp B?
Explain your answer.

As the height above the ground is the same for both ramps, **the same amount of work / energy** is done.

(ii) Explain how the two ramps differ in terms of the **force** and **power** needed to ride up them.
Calculations are not required.

As the work done is the same and $P = W / t$, the **time** taken to go up Ramp A is greater and so **the power used is less** going up Ramp A. As the work is the same, but the **distance** is greater for Ramp A, and $W = F \times d$, **the force needed is less** on Ramp A.

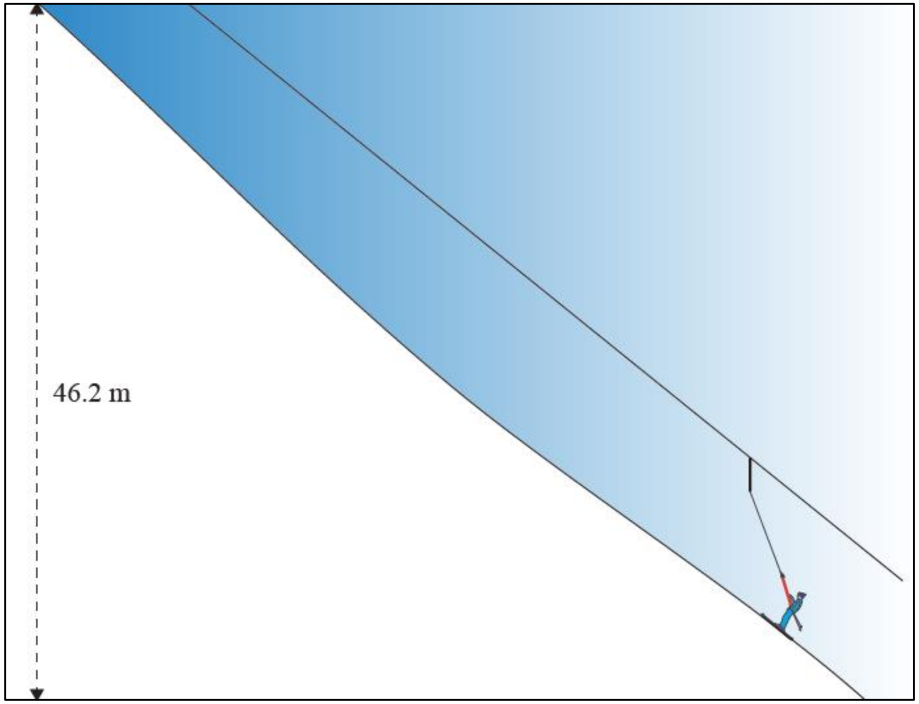
Excellence Question

NCEA 2018 Work and Power – Skiing

Question 3a : Marama is snow skiing and uses a ski tow to get to the top of the slope. The ski tow pulls Marama up the slope to a height of 46.2 m. The combined mass of Marama and her ski gear is 62 kg.
(a) Calculate the work done for Marama to reach the top of the slope.

$F_w = m \times g = 62 \times 10$
$= 620$ N
$W = F \times d = 620 \times 46.2$
$= 28\ 644$ J

3b: It takes 525 s for the tow to pull Marama to the top of the slope.
Calculate the power needed to get Marama to the top. For this question, ignore friction.



$P = W / t$
$= 28\ 644 / 525$
$= 54.6$ W
(Sig. figs not required.)

Merit Question

NCEA 2019 Work – Walking in sand

Question 2c : The adult's weight force does 21 J of work on the sand.
Calculate the distance the adult's feet sink into the sand.
The adult has a weight of 690 N.

W= Fd

d = W/F = 21/690 = 0.0304m

Energy can exist as potential or kinetic energy

Energy can be classified into two types; **kinetic energy** (E_k) and **potential energy** (E_p)

Kinetic energy is seen when particles, waves or objects move. We will be focusing on **mechanical kinetic movement**, the movement of objects.

All forms of stored energy are called potential energy – this can not be seen until it is transformed (changed) into active energy. We will be focusing on **gravitational potential energy**, the stored energy objects gain when moved to a height.

Mechanical kinetic Energy

Movement energy. This can be seen when matter changes its position in space

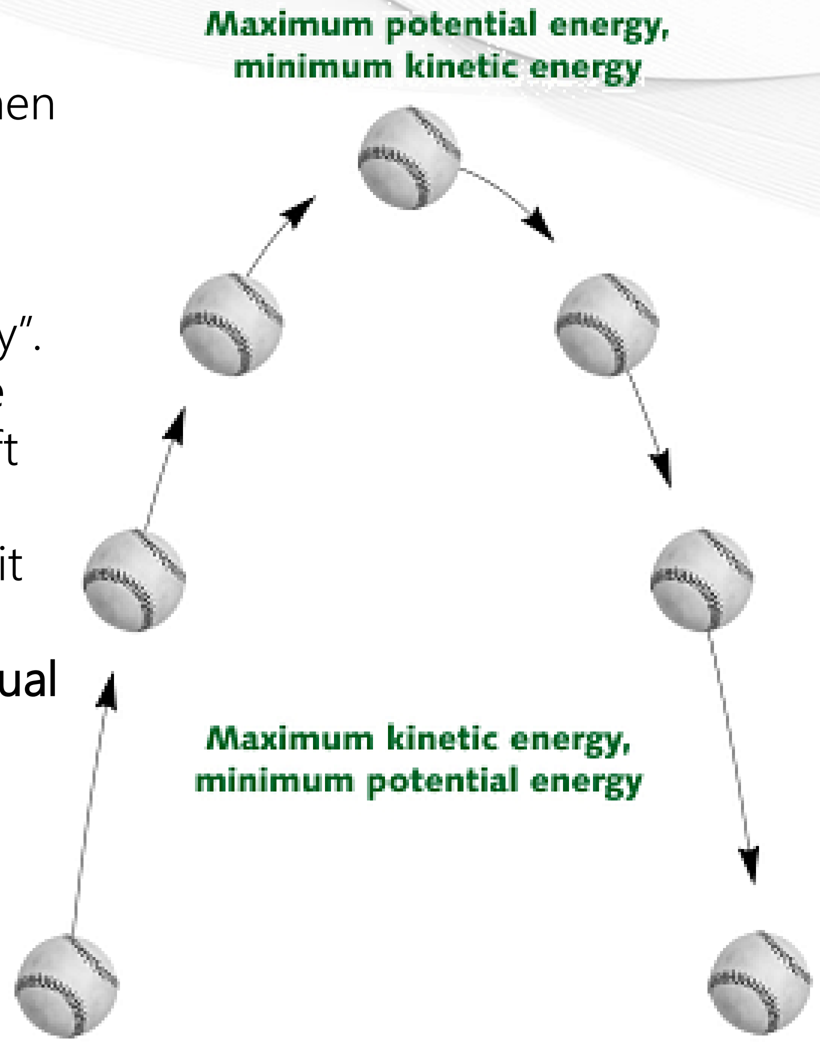
Gravitational potential Energy

This is the energy contained by an object which pulls it back to Earth. The further up from the ground, the more it contains.

Conservation of Energy

The law of conservation of energy says that **energy is neither created nor destroyed**. When we use energy, it does not disappear. It **transforms from one form of energy into another**.

Conservation of energy is not "saving energy". Kinetic and potential energy often exchange one form of energy for another. When we lift an object, it is given gravitational potential energy. Work is done on the object to raise it against the gravitational field of the Earth. **The change in potential energy is always equal to the change in kinetic energy.** (Assuming there are no other energy losses). When an object falls back down the gravitational potential energy it had transforms back into kinetic energy.



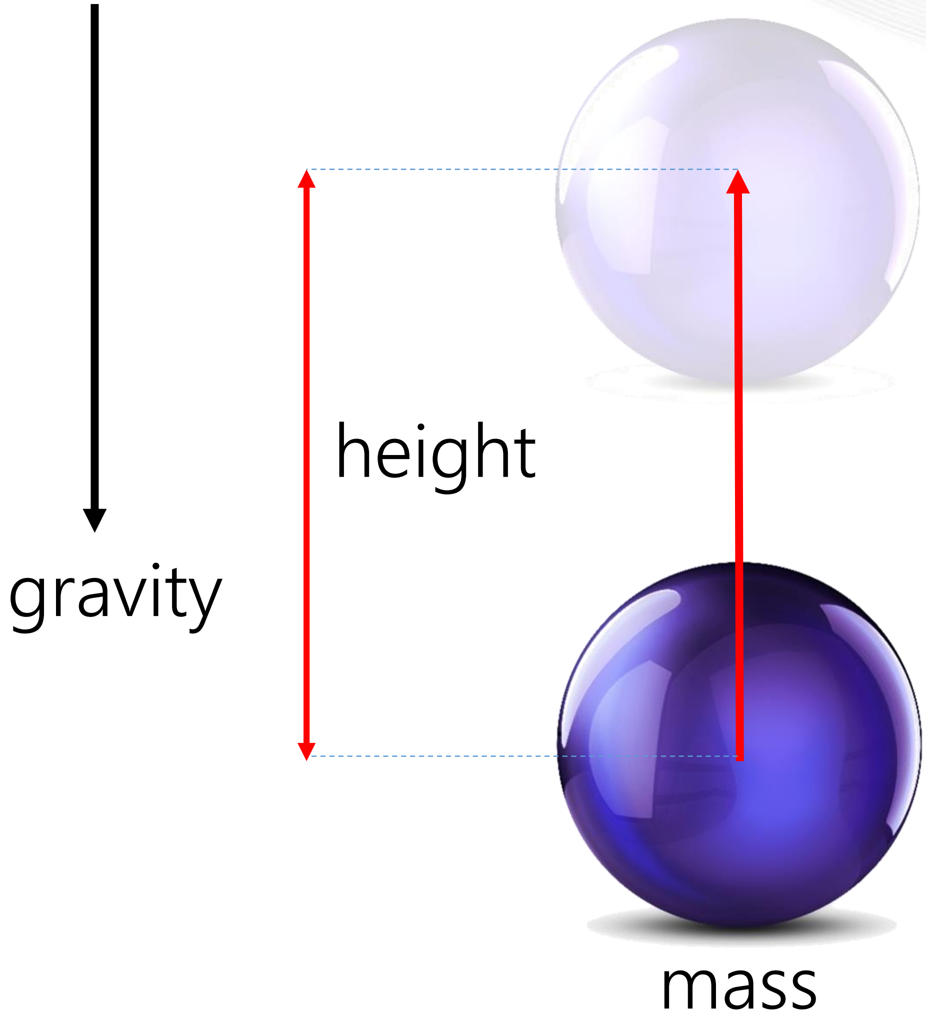
$$\Delta mgh = \Delta \tfrac{1}{2}mv^2$$

Potential energy

Potential energy = mass x gravity x height

Potential energy is dependent on the mass of an object, the height it is at and the force of gravity upon it. Objects with mass have stored potential energy (E_p) when they are raised above the centre of gravity.

Objects with more mass will gain more gravitational potential energy than objects of smaller mass when they are both raised to the same height.



Calculating Potential energy

Remembering **F_w = m x g** that if weight is given rather than mass, then this can be directly multiplied with height (in metres) to calculate gravitational potential energy.

In many situations, calculating the energy gained can also be done using **W = F x d** if the distance is vertical (straight up and down) due to work due to work being done when a force is applied to an object of mass and moves it over a distance.

$$E_p = mg\Delta h$$

E_p = potential energy (J)
g = acceleration by gravity (ms^{-2})
m = mass (kg)
h = height (m)

GZ Science Resources

Kinetic energy

An object has **kinetic energy** when it is moving.
Kinetic energy that an object contains depends upon both its mass and the velocity that it is moving.

Kinetic energy = 0.5 x mass x velocity²

An object that has the same mass as another but is travelling at a greater velocity will contain far more kinetic energy.
An object with more mass will possess greater kinetic energy than an object with less mass that is traveling at the same velocity.

$$E_k = \frac{1}{2}mv^2$$

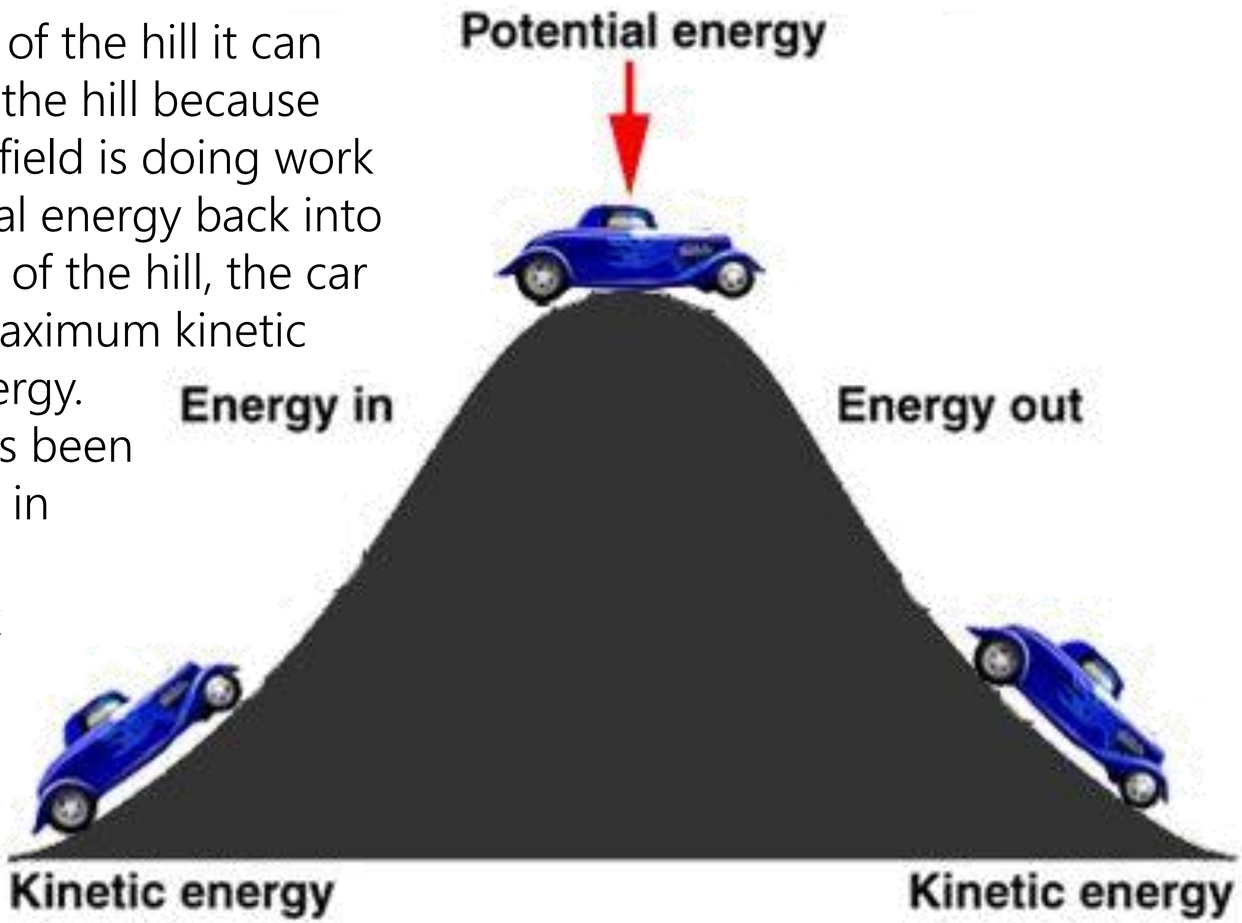
E_k = Kinetic energy (J)
m = mass (kg)
v = velocity (ms^{-1})

Conservation of Energy - Example

For a car driving to the top of a hill, the kinetic energy is transformed into gravitational potential energy. Work is being done by the engine on the car because energy is being transformed from one form into another.

When the car gets to the top of the hill it can coast down the other side of the hill because now the Earth's gravitational field is doing work on the car to convert potential energy back into kinetic energy. At the bottom of the hill, the car has maximum velocity and maximum kinetic energy but zero potential energy.

All of the potential energy has been converted into kinetic energy in the process of the Earth's gravitational field doing work on the car.



Loss of Energy during transformation

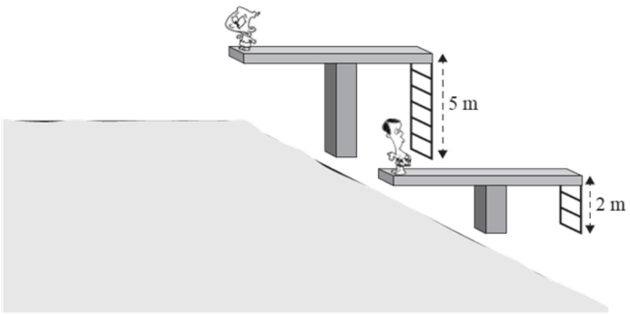
Mention **BOTH** surfaces that act against each other to transform kinetic energy into heat and sound energy due to friction

In reality, **100% of gravitational potential energy is not transformed** into kinetic energy at each transformation. For example, a child swinging will gradually slow down and not swing up to the same height each time.

Whenever an object is moving, there will be **friction**, with water, air particles or another surface. This will cause some of the energy at each transformation to change into **heat** energy. This reduces the total amount available for transformation. In some cases, energy can also be changed into **light and sound energy** and unavailable for transformation. Without a further input of energy, an object will eventually come to rest.

Conservation of Energy

Question 1d: Ian jumps into the pool from the 5 m platform.
Calculate Ian's speed as he is about to hit the water (assuming conservation of energy).
In your answer you should:
- name the types of energy Ian has before he jumps, AND as he is about to hit the water
- calculate Ian's speed as he is about to hit the water.



$E_k = ½mv^2$

E_k = Kinetic energy (J)
m = mass (kg)
v = velocity (ms^{-1})

$E_p = mgh$

E_p = potential energy (J)
g = acceleration by gravity (ms^{-2})
m = mass (kg)
h = height (m)

How do we answer this question?
Ian had gained gravitational potential energy at the top of the diving board and this was converted into kinetic energy.
We assume that all gravitational potential energy will equal the kinetic energy.

If question states assuming conservation of energy then Ek = Ep

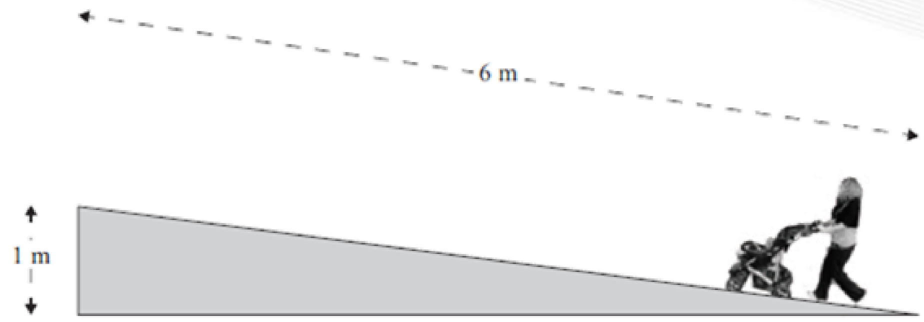
$$E_k = E_p$$
$$\frac{1}{2}mv^2 = mgh$$
$$v^2 = 2gh$$
$$v = \sqrt{2gh}$$
$$v = \sqrt{2 \times 10 \times 5}$$
$$v = 10 \text{ m s}^{-1}$$

Substitute one type of energy for the other then rearrange equation to find value.

2012 NCEA Work and 'missing' energy – the buggy

Q1: A woman pushes a child in a buggy up a ramp as shown below with a force of 100N. **Calculate the work done** to push the buggy and child up the ramp

$W = F \times d$
$= 100 \times 6 = 600$ J



Q2: The energy gained by the buggy and child (m = 55 kg) at the top of the ramp **does not equal** the work done. Explain why these two values are not equal.
In your answer you should:
- name the type of energy the buggy has, when it reaches the top of the ramp
- calculate the difference between the work done and the energy at the top of the ramp
- explain where the "missing" energy has gone and why this occurs.

Type of energy at top is **gravitational potential energy**
$E_p = mgh = 55 \times 10 \times 1 = 550$ J
Energy difference = 600 – 550 = 50 J

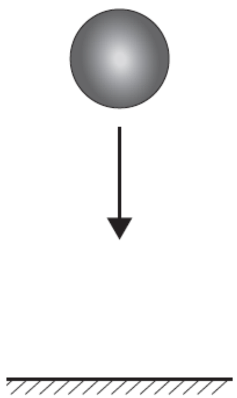
More energy is used to get up the ramp as some of the energy is being **converted into heat** (and sound), due to friction between the wheels and ramp, or the buggy's moving parts.

NCEA 2013 Conservation of Energy - The ball

Merit Question

Question 2a: In a classroom experiment, a ball is dropped onto the floor. Before the ball is dropped, it is not moving, and has only gravitational potential energy (*E*p). As the ball falls, the gravitational potential energy is converted into kinetic energy (*E*k).
The ball has a mass of 100 grams.
(a) Complete the labels for the diagram below to show the energy changes as the ball is dropped.
Assume that the gravitational potential energy is changed **only** into kinetic energy.

Assume conservation of energy



At the top: $E_p = 0.2$ J $E_k = 0$ J

Halfway: $E_p =$ ________ $E_k =$ ________

Just before it hits the floor: $E_p =$ ________ $E_k =$ ________

Halfway:
$E_p = 0.1$ J $E_k = 0.1$ J
At the bottom:
$E_p = 0$ J $E_k = 0.2$ J

NCEA 2013 Conservation of Energy - The ball (part 2)

Excellence Question

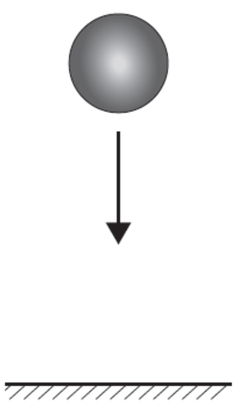
Question 2b: The teacher tells the students that the ball will be travelling at 2 m s^{-1} just before it hits the floor. The students are asked to predict the speed of the ball halfway down from three options:

Option 1: The speed is **less** than 1 m s^{-1}.

Option 2: The speed is **equal** to 1 m s^{-1}.

Option 3: The speed is **greater** than 1 m s^{-1}.

State the correct option, explain your answer, and support your answer using energy calculations. (The ball has a mass of 100 grams.)



Option 3.

At halfway $E_k = 0.1\text{ J} = ½mv^2 = ½ \times 0.1 \times v^2$

$v^2 = 2$

$v = 1.41\text{ m s}^{-1}$

Assume conservation of energy and rearrange equation to find velocity

2014 NCEA 'missing' energy – the crane

Question: A crane was lifting wood. The cable broke, and 150 kg of wood fell 12 m to the ground below. The wood had 15 000 J of kinetic energy just before it landed on the ground below. This was different from the amount of energy the wood had when it was hanging from the crane. Explain why there is a difference in the energy the wood had when it was hanging from the crane compared to just before it hit the ground.

In your answer you should:

- name the type of energy the wood had when it was hanging from the crane
- calculate how much energy the wood had when it was hanging from the crane
- calculate the difference between the kinetic energy of the wood just before hitting the ground and the energy the wood had when it was hanging from the crane
- justify the difference in energy of the wood when it was hanging from the crane and then just before it hit the ground.

Answer: At the top, the wood has a certain amount of gravitational potential energy and no kinetic
energy. Just before the wood hits the ground, the gravitational potential energy has been converted into kinetic energy. **Some kinetic energy is lost as heat energy** due to the frictional force of air resistance.

$E_P = mgh = 150 \times 10 \times 12 = 18\,000$ J

Difference between E_P and E_K: $= 18\,000 - 15\,000 = 3\,000$ J

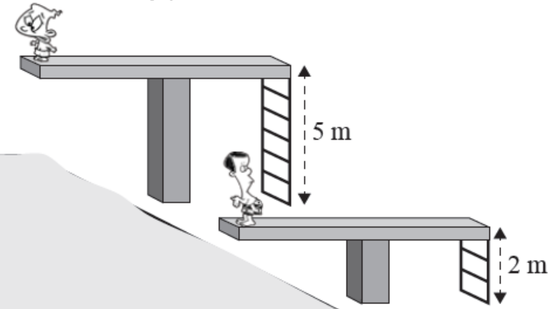
NCEA 2015 Conservation of Energy - the diver

Excellence Question

Question 1d: Ian jumps into the pool from the 5 m platform.
Calculate Ian's speed as he is about to hit the water (assuming conservation of energy).
In your answer you should:

- name the types of energy Ian has before he jumps, AND as he is about to hit the water
- calculate Ian's speed as he is about to hit the water.

Answer 1d: Ian had gained gravitational potential energy at the top of the diving board and this was converted into kinetic energy.
We assume that all gravitational potential energy will equal the kinetic energy.



OR

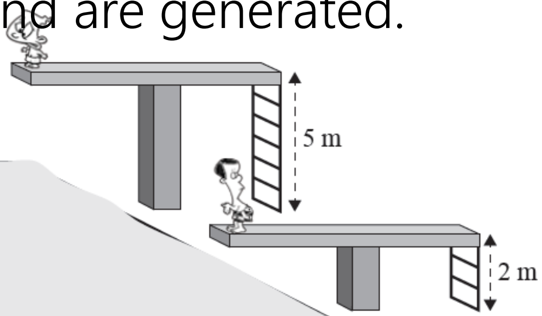
$$E_k = E_p$$
$$\frac{1}{2}mv^2 = mgh$$
$$v^2 = 2gh$$
$$v = \sqrt{2gh}$$
$$v = \sqrt{2 \times 10 \times 5}$$
$$v = 10 \text{ m s}^{-1}$$

NCEA 2015 'missing' Energy - the diver

Excellence Question

Question 1e: Explain why Ian's actual speed as he is about to hit the water, is slower than that calculated in part (d).

Answer 1e: There are some losses of energy due to friction / air resistance. This means that some of the initial gravitational potential energy is converted into heat and sound as well as kinetic energy. As a consequence, the kinetic energy is less than that calculated (theoretical value), and the boy enters the water at a slower speed. Air resistance / friction occurs as the boy falls, because the boy is pushing past air particles. As the air particles rub against the boy, heat and sound are generated.



Explain that air resistance / friction causes losses of energy AND the energy is converted into heat and / or sound
AND that, as the kinetic energy (energy of motion) is less, the boy enters the water at a slower speed.

NCEA 2016 Conservation of Energy - The Rocket

Excellence Question

Question 3c: A small rocket has a mass of 2.60 kg and a weight of 26.0 N. The rocket had gained 1950 J of potential energy at its maximum height. It then fell back to the ground.
What was the maximum speed it could reach just before hitting the ground (assuming energy is conserved)?

Answer 3c: $E_p = E_k$

$E_k = 1950$

$E_k = \frac{1}{2} mv^2$

$1950 = \frac{1}{2} \times 2.60 \times v^2$

$v = \sqrt{1950 \times \frac{2}{2.60}}$

$v = 38.7 \text{ m s}^{-1}$ (3sf)

(Sig. figs not required.)

Excellence Question

NCEA 2017 Conservation of Energy – The Crane

Question 3d: The crane was lifting another container and the cable broke. The 6500 kg container fell 15 m to the ground below. The container had 970 000 J of kinetic energy just before it hit the ground.
Calculate the energy the container had before the cable broke. **AND**
Explain why there is a difference in the energy of the container when it was hanging from the crane compared to just before it hit the ground.

$E_P = mgh = 6500 \times 10 \times 15 = 975\ 000$ J
Difference between E_P and E_K: $= 975\ 000$ J $- 970\ 000$ J $= 5\ 000$ J

At the top, the container has a certain amount of gravitational potential energy and no kinetic energy.
Just before the container hits the ground, the gravitational potential energy has been converted into kinetic energy.There are some losses of energy due to frictional force of air resistance. This means that some of the initial gravitational potential energy is converted into heat and sound as well as kinetic energy. Air resistance / friction occurs as the container falls, because the container is pushing past air particles. As the air particles rub against the container , heat and sound are generated

As a consequence, the kinetic energy is less than that calculated (theoretical value) using the assumption of conservation of energy

http://www.nauticexpo.com/prod/liebherr-international-

Excellence Question (i) + (ii)

NCEA 2018 Conservation of Energy – Skiing

Question 3c : Jake has a mass of 75 kg and is doing a jump. He has 3200 J of gravitational potential energy at the top of his flight.
(i) Calculate his downward (vertical) speed just before he lands, assuming energy is conserved.

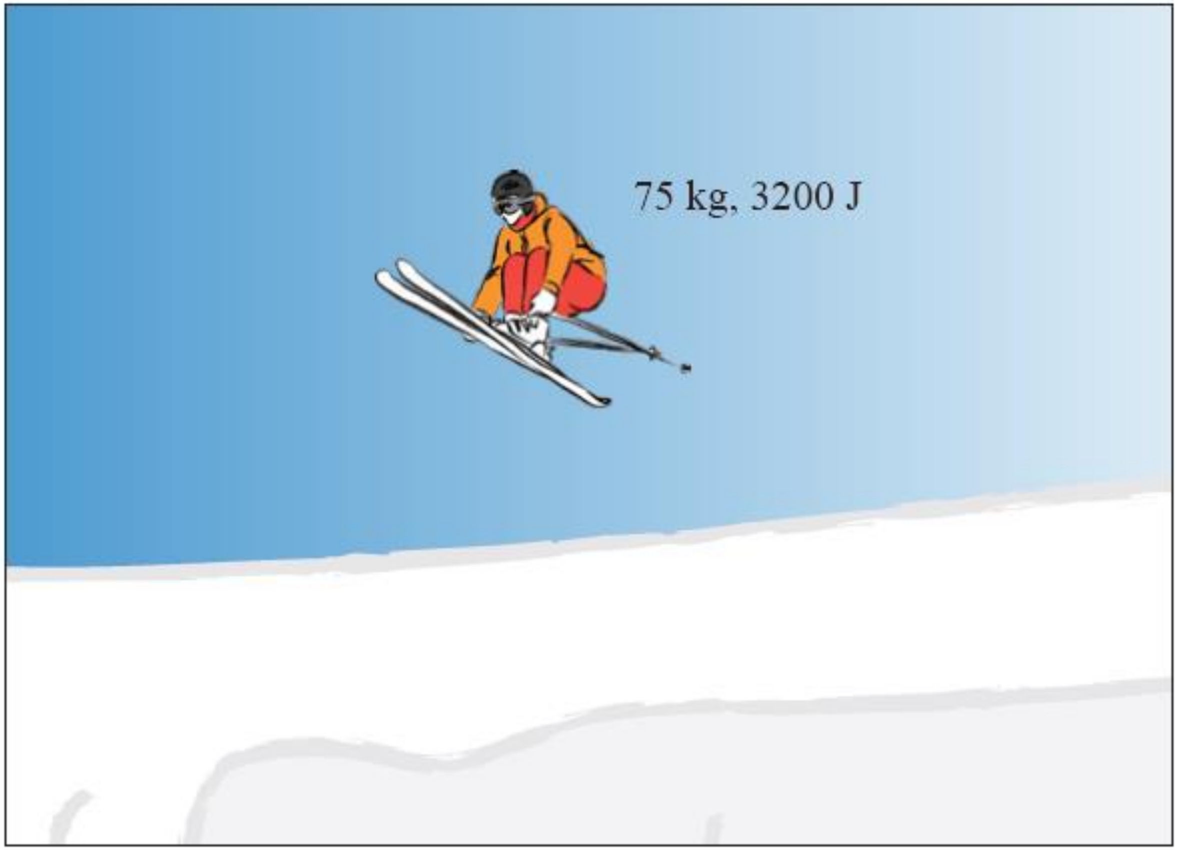
Jake had gravitational potential energy at the top of the jump, and
this was converted into kinetic energy.
If energy is conserved, we assume that all gravitational potential
energy will equal the kinetic energy.

$E_P = E_K$

$3200 = 1/2 \times 75 \times v^2$

$$v = \sqrt{\frac{3200}{0.5 \times 75}}$$

$= 9.24 \text{ m s}^{-1}$

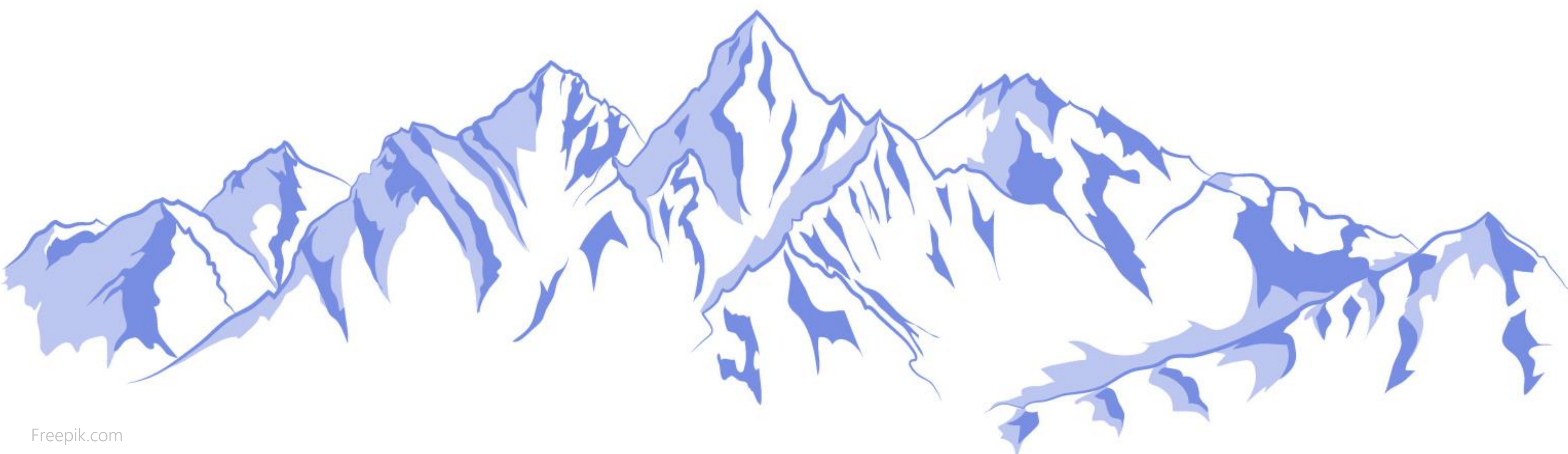


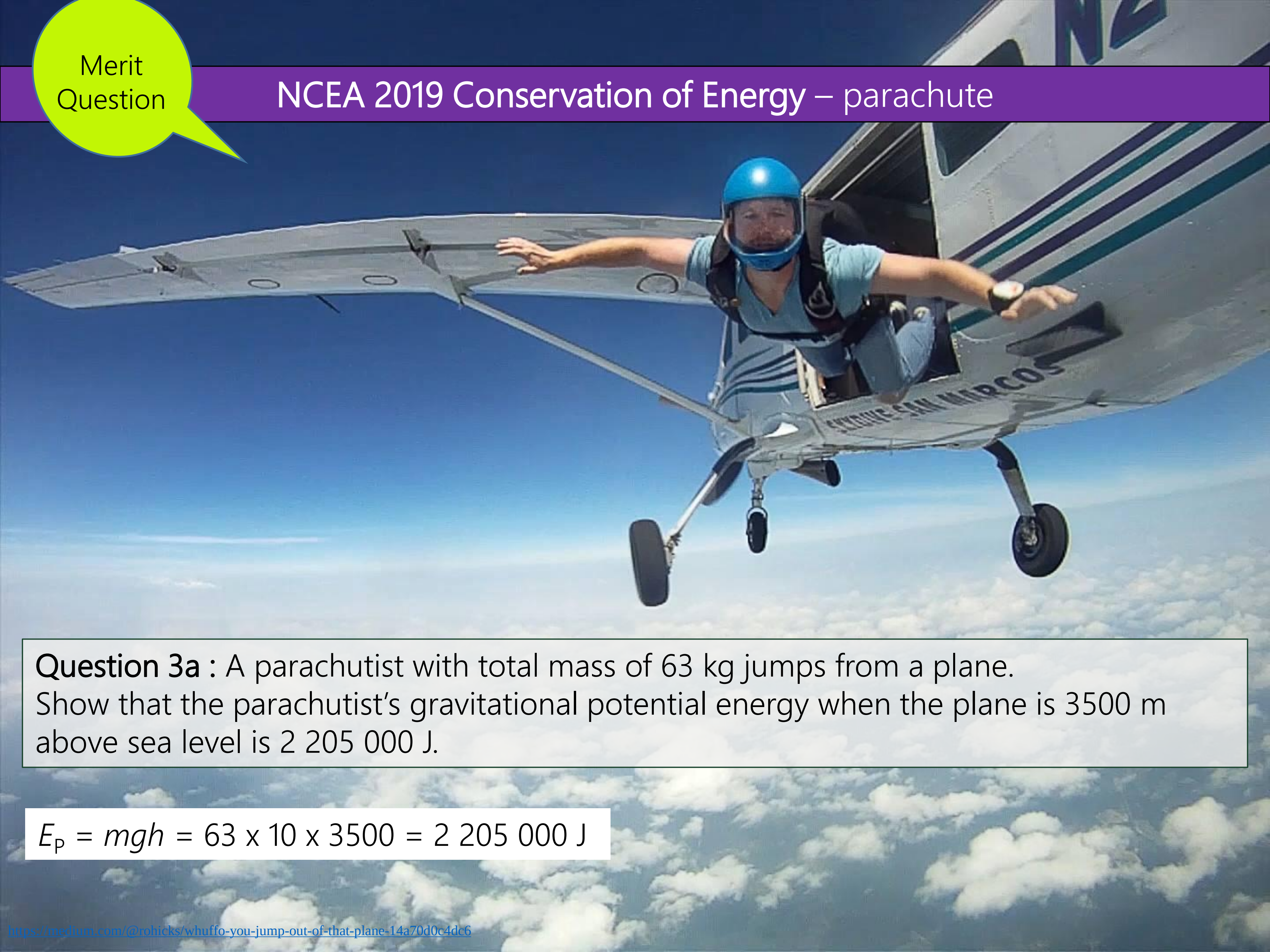
Excellence Question (i) + (ii)

NCEA 2018 "Missing" Energy – Skiing

Question 3c : Jake has a mass of 75 kg and is doing a jump. He has 3200 J of gravitational potential energy at the top of his flight.
(ii) Explain why Jake's actual speed when he lands is slower than that calculated in part (i).

There are some losses of energy due to friction / air resistance. This means that some of the initial gravitational potential energy is converted into heat and sound, as well as kinetic energy. As a consequence, the kinetic energy is less than that calculated (theoretical value), and Jake hits the snow at a slower speed. Air resistance / friction occurs as Jake falls, because he is pushing past air particles. As the air particles rub against Jake, heat and sound are generated.





Merit Question

NCEA 2019 Conservation of Energy – parachute

Question 3a : A parachutist with total mass of 63 kg jumps from a plane. Show that the parachutist's gravitational potential energy when the plane is 3500 m above sea level is 2 205 000 J.

$E_P = mgh = 63 \times 10 \times 3500 = 2\ 205\ 000$ J

https://medium.com/@rohicks/whuffo-you-jump-out-of-that-plane-14a70d0c4dc6

Excellence Question

NCEA 2019 Conservation of Energy – parachute

Question 3d : During the 450 m fall, the parachutist's gravitational potential energy was reduced by 283 500 J.
Calculate the parachutist's downward speed (vertical) at 450 m, assuming energy is conserved.

$\Delta E_P = E_k$
$E_k = 283\ 500$

$E_k = ½\ mv^2$

$283\ 500 = ½\ 63 \times v^2$

$v^2 = 2 \times 283\ 500 / 63$

$$v = \sqrt{9000} = 94.9 \text{ m s}^{-1} = 95 \text{ m s}^{-1} \text{ (2 sig.fig.)}$$

"Missing" Energy

Question: A crane was lifting wood. The cable broke, and 150 kg of wood fell 12 m to the ground below. The wood had 15 000 J of kinetic energy just before it landed on the ground below. This was different from the amount of energy the wood had when it was hanging from the crane. Explain why there is a difference in the energy the wood had when it was hanging from the crane compared to just before it hit the ground.

In your answer you should:

- name the type of energy the wood had when it was hanging from the crane
- calculate how much energy the wood had when it was hanging from the crane
- calculate the difference between the kinetic energy of the wood just before hitting the ground and the energy the wood had when it was hanging from the crane
- justify the difference in energy of the wood when it was hanging from the crane and then just before it hit the ground.

How do we answer this question?

At the top, the wood has a certain amount of gravitational potential energy and no kinetic energy. Just before the wood hits the ground, the gravitational potential energy has been converted into kinetic energy.

Link type of energy to position

Some kinetic energy is lost as heat energy due to the frictional force of air resistance. (and also sound energy) so not all of the gravitational energy was remaining to convert into 100% kinetic energy

Explain that the "missing energy" was due to friction converting a portion into heat energy

$E_P = mgh = 150 \times 10 \times 12 = 18\,000$ J

Difference between E_P and E_K: $= 18\,000 - 15\,000$

$= 3\,000$ J

Use equation to demonstrate explanation