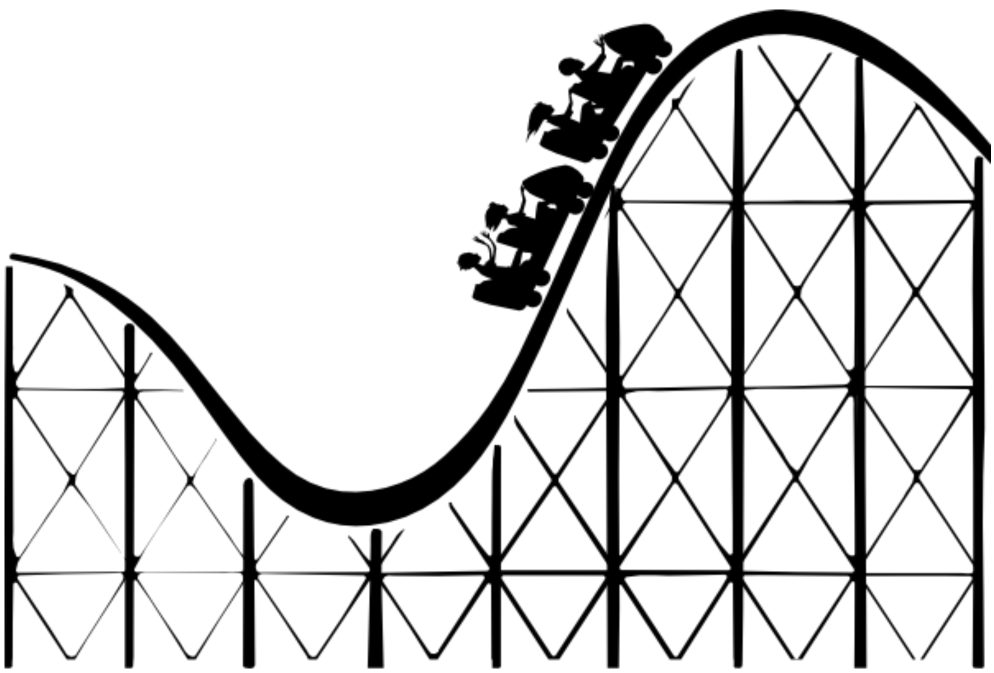
Year 10 Science – General

Physics 2021

Forces, Motion and Energy



NAME: ____________________________________

FORM: ____________________________________

TEACHER: ____________________________________

Physics Formulae and Data

Speed: $speed_{av} = \frac{distance}{time}$ OR $speed = \frac{d}{t}$

Velocity: $v_{av} = \frac{s}{t}$

Acceleration: $a = \frac{v-u}{t}$ OR $v = u + at$

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

Reaction distance: $s = ut_R$ where t_R = reaction time

Braking distance: $s = \frac{1}{2}ut_B$ where t_B = braking time

Newton's 2nd Law: $a = \frac{F}{m}$ OR $F = ma$

Weight (force) $W = mg$ given that on Earth g = 9.80 m/s^2

Work: $W = Fd$ OR W = change in energy

Kinetic Energy: $\mathrm{KE} = \frac{1}{2}mv^2$

Maximum velocity of a falling object: $v = \sqrt{\frac{2\mathrm{KE}}{m}}$

Potential Energy: $\mathrm{PE} = mgh$

Energy Efficiency: $\%\text{efficiency} = \frac{\text{useful energy}}{\text{total energy}} \times 100$

Distance and Displacement

Flashcard Vocab: displacement, displacement-time graph, distance, kilometre, metre, scalar, SI, vector, vector addition, vector diagram

Demo: Trundle wheel shortcut

Watch your teacher trundle around the room from point A to point B.
Sketch the distance travelled using straight lines labelled in metres.
Then sketch the direct route measurement from A and B.

Created by Eucalyp
from Noun Project

The length of path from A to B was the distance travelled, equal to _____ m.

The direct route from A to B, the actual change of position, was equal to _____ m in length.

The direction from A to B was __________.

We say that the teacher's displacement from A to B was _____ m ___________.

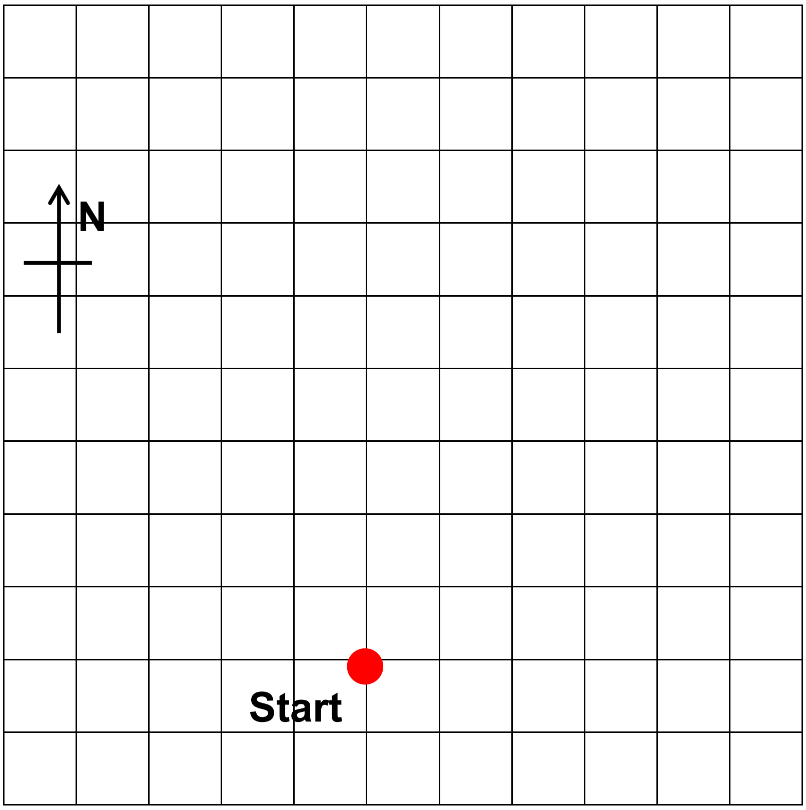
The direction from B to A would be __________. The way the arrow points gives the direction.

- ♦ **Distance** is how far an object has moved (travelled), i.e. the total length of the path taken.
  - The standard (SI) unit of measurement for distance is the **metre** (**m**).
  - We often measure distances in kilometres (km) for convenience. 1 km = 1000 m
- ♦ **Displacement** is the straight line distance from starting point to finishing point in the direction of travel, i.e. an object's change in position.
  - Memory trick: dis-placed = "moving from DIS place to DAT place").
  - Measured in (m) or (km) and *must* include direction.
  - Direction can be up, down, left, right, forward, back, or any compass direction (e.g. N, S, E, W etc.).

Example

Three friends are on their way to Kings Park. They travel 2 km east, then 6 km north, then 3 km northeast and finally 1 km west.

a) Draw a scale diagram of their trip, using a ruler to draw straight lines (1 cm = 1 km). Each leg of the journey should have an arrow to indicate direction of travel.
b) Use a ruler to measure the total distance travelled in cm and convert to km.
c) Use a protractor to measure the overall direction of travel.
d) Write down the displacement of the three friends.



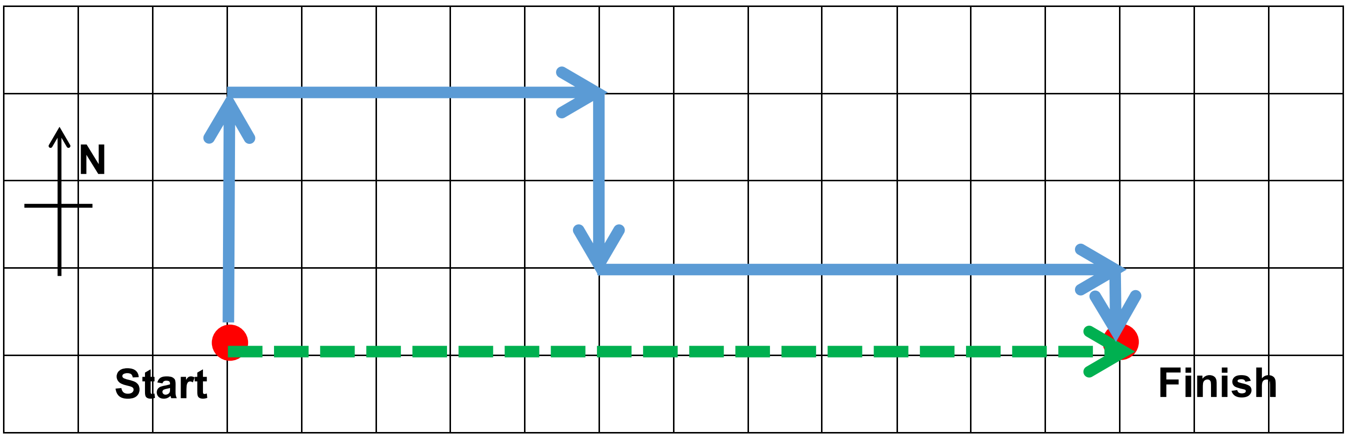
Distance: ___________ Displacement: ______________________

Practice Exercises

Find the distance and displacement for each journey.

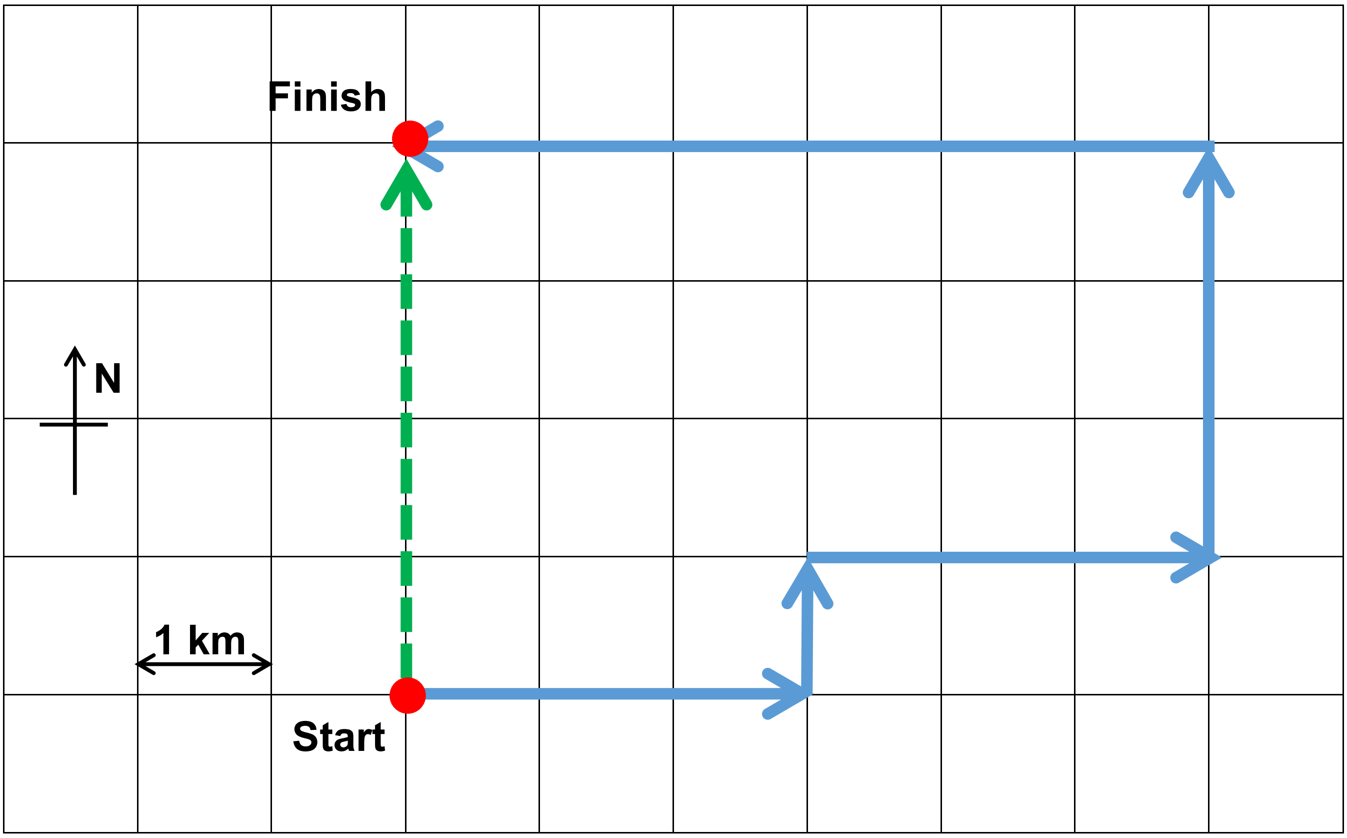
In each diagram, the solid arrows show the route walked. A dashed arrow shows the change in position, the shortest length between the start and the finish of the journey.

1.



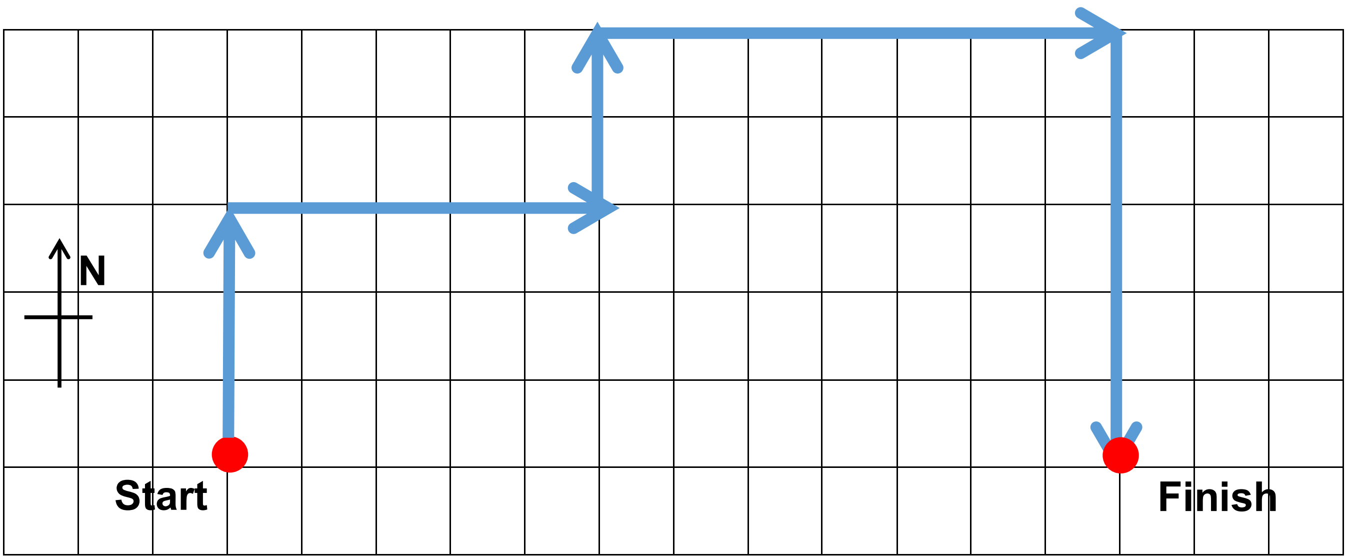
Distance: ___________ Displacement: ______________________

2.



Distance: ___________   Displacement: ______________________

3.



Distance: ___________   Displacement: ______________________

Could displacement ever be bigger than distance? _____

Could displacement ever be equal to distance? _____

Describe a journey in which displacement is 0 but distance is not.

____

Lab: Bringing graphs to life (cf. O10.p221)

As a group, find a space and act out the motion shown in the graph. Estimate 1 m as a large step, and estimate seconds by counting "one thousand, two thousand…"

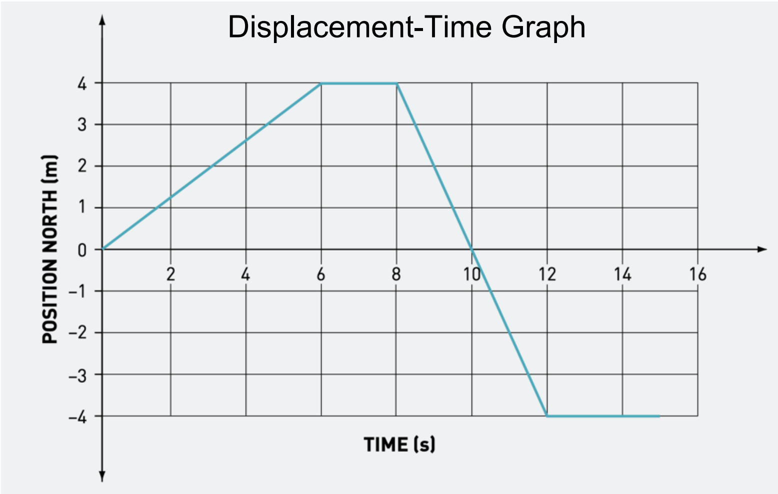
What distance did the walker travel?

____

What was their displacement?

____

When were they moving fastest? How can you tell from the graph?



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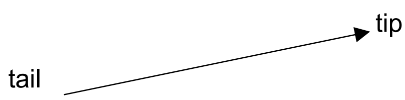
Scalars and Vectors

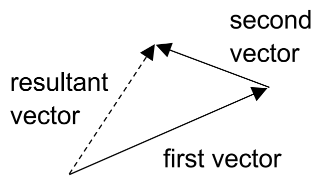
- Measured quantities are either scalar quantities or vector quantities.
  - **Scalars** measure only size (or magntitude), such as **distance**, **speed**, mass, and time.
    - E.g. a <u>distance</u> of <u>20 m</u>
  - **Vectors** measure size and also direction, like **displacement**, **velocity**, and force.
    - E.g. a <u>displacement</u> of <u>20 m north</u>
  - Note that vectors cannot be fully described unless direction is included.

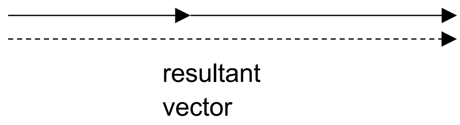
- Vectors are represented using **arrows**. The **length** indicates **magnitude** (size). The pointing **arrowhead** indicates **direction**. The end with the arrow is the 'tip'; the other end is the 'tail'.



- A **vector diagram**, which shows direction, can be drawn to help us solve problems by adding vectors.
- The sum of any number of vectors can be found using a method known as **vector addition**.
- Vectors are added by drawing each vector "tip to tail". The tail of a second vector must be joined to the tip of the first.
- A (third) vector is then drawn connecting **the tail of the first to the tip of the last** in the chain. It is called the **resultant vector**. Any number of vectors can be added this way.

E.g.





Worked Example

- A person walks 200 m east, pauses, and then continues 400 m east. Find their displacement (total change in position, with direction) by constructing a simple vector diagram and adding the vectors.

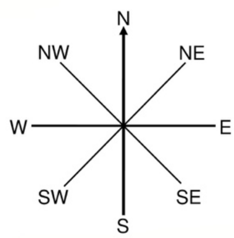
- If the same person now continues travelling and walks 800 m west, what is their new displacement?

Practice Example

A cat climbs a ladder to a height of 2.4 m before slipping down to a height of 1.1 m where it stops. Draw a labelled vector diagram to calculate its displacement. Remember to include direction!

Compass directions

Besides simple directions such as "up, down, left, right", compass directions are often used. You should be familiar with the layout of a compass, as shown.



Exercise Set I

Collect the review worksheet, complete it, and mark your work using the answers provided.

Worksheet: "Distance and Displacement"

Speed

Flashcard Vocab: speed, average speed, instantaneous speed, metre per second

- **Speed** is a measure of how fast an object is moving.
  - It tells us how far the object has travelled in each unit of time.
  - The standard (SI) unit of measurement for speed is **metres per second** (**m/s**).
  - We often use **kilometres per hour** (**km/h**) for everyday measurements of speed.

Examples:

1. A car travelling at 50 km/h:
   - Each hour the car travels 50 km.
   - In 1 hour it will have travelled 50 km.
   - In 2 hours it will have travelled 100 km.
2. A person walking at 5 m/s:
   - Each second is walking 5 m.
   - In 1 minute would walk 5 x 60 = 300 m.

Activity: Comparing speeds

Use the list of animal speeds to answer these questions.

Animal	Speed (km/h)
Peregrine Falcon	389
Cheetah	121
Ostrich	97
Blue Wildebeest	80
Lion	80
Hare	80
Kangaroo	71
Horse	69
Human	43
Bearded Dragon	40
Sailfish	109
Coyote	64

1. Which animal is fastest? How do you think it achieves this?

   ____

   ____

   ____

2. Who wins a race between a top human athlete and a bearded dragon?

   ____

3. How successful do you think lions are at catching hares? Explain. ____________________

   ____

   ____

4. Approximately how many times faster is a cheetah than an average human?
   (<u>Hint</u>: Estimate an average human's top speed.)

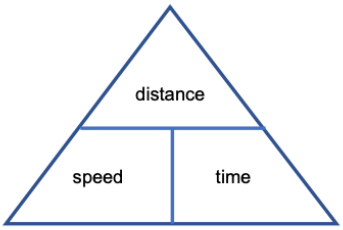
   ____

Calculations

- Speed is found by dividing the total distance travelled by the time it took.

$$speed = \frac{distance}{time}$$

$$speed = \frac{d}{t}$$



Problem-solving steps

List the data given.

↓

Write down what has to be found.

↓

Write down the equation.

↓

Substitute the data in place of the letters.

↓

Calculate the answer.

↓

Check units and underline answer.

- The triangle can be used to find each quantity.
  Cover the one you want with your thumb.

$$d = speed \times t$$

$$t = \frac{d}{speed}$$

Worked Examples

1. A car travels 210 km along the freeway in 3 hours. Calculate its average speed.

2. A bus travels at 100 km/h for 85 km. How long was the bus trip? Give your answer in both hours and minutes.

3. It takes you 30 minutes to get to work when you drive your car along a direct route at 70 km/h. How far is work from your home?

Practice Examples

1. In 1990, Glenn Spear set a world record by swimming the 50 m freestyle in 21.81 s. What was Glenn's average speed?

2. A car is going 35 km/h to reach its destination 175 km away. How long will it take to reach its destination?

3. How much time passes when an object travels at a constant speed of 18.46 m/s over a distance of 18.90 m?

Average Speed

- When we calculate speed, we are usually finding the **average speed** for the whole trip. At any moment in time, the object can actually be moving faster or slower than the average.
- **Instantaneous speed** is the speed of an object at an instant (a moment) in time.
  E.g. The speedo of a car gives the instantaneous speed only.

Worked Example

A motorist was caught driving at 85 km/h in a 70 zone and was fined for speeding. But the driver claimed that she could not have been speeding because she had travelled 30 km from home to work between 7:00am and 7:30am, meaning that her average speed was well below the speed limit. Explain why her claim was rejected!

Lab: The ticker timer (cf. O10.p222)

Follow your teacher's instructions to complete this experiment.

Paste two strips from the ticker timer here, one for a fast speed, and one for a slow speed.

Lab: Sprinters!

Follow your teacher's instructions and the steps on the lab sheet.

Exercise Set II

Collect the review worksheet, complete it, and mark your work using the answers provided.

Worksheet: "Speed"

Units and conversions

- Scientists use a standard set of units based on the metric system of measurement which uses multiples of 10. It is important to be able to convert between them.

The prefix 'milli'

Think! Is a 600 mL carton of milk more than or less than a 1L carton of milk? ___________

- When a unit has the prefix '**milli**' (**m**) it always means **one thousandth of the standard unit**. So one millimetre is always one thousandth of a metre. Turning this around, there must always be one thousand millimetres in one metre, or 1000 mm = 1 m.

Examples

1. How many mL are there in a L? ___________
2. How many mm are there in a m? ___________
3. How many ms are there in a s? ___________

The prefix ‘kilo’

- When a unit has the prefix ‘**kilo**’ (**k**) it always means **one thousand of the standard unit**. One kilometre is 1000 metres, so 1000 m = 1 km.

Examples

1. How many grams are there in a kilogram? ___________
2. How many metres are there in a kilometre? ___________

Other prefixes

- We will mostly use ‘kilo’ and ‘milli’, but other common prefixes are used to indicate very large or very small numbers.

Prefix	**Symbol**	**Factor**	**Example**
giga	G	1 000 000 000	1GJ is one billion joules
mega	M	1 000 000	A megawatt is one million watts
kilo	k	1000	1 kg is one thousand grams
centi	c	0.01	1 cm is one hundredth of a metre
milli	m	0.001	1 mm = one thousandth of a metre
micro	μ	0.000 001	1 m is one million micrometres
nano	n	0.000 000 001	1 nanometre is one billionth of a metre

Note that a “big M” has a very different meaning than a “little m”.

Examples

1. Convert 34 mm to m.

2. Convert 2.4 kL to mL.

Converting units of time

- Units of time are not based on the metric system because they relate to the Earth’s rotation on its axis (day) and its revolution around the Sun (year).

Examples

1. Convert 2 h to s.

2. Convert 1 year to s.

A good way to remember the standard units of measurement for the quantities **length**, **mass** and **time** is "**mks**":

length	*mass*	*time*
metre, **m**	kilogram, **k**g	second, **s**

Converting between m/s and km/h

- ♦ Since we mostly use standard units (e.g. metres, seconds) we usually convert km/h to m/s.

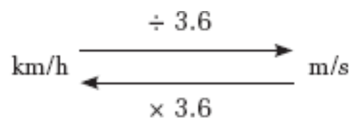
$$1\ km/h = \frac{1\ km}{1\ h} = \frac{1000\ m}{(60\ \times\ 60)\ s} = \frac{1000\ m}{3600\ s} = \frac{1}{3.6}\ m/s$$

This means that 1 m/s = 3.6 km/h. The conversion factor we need to remember is 3.6.

Worked Example

A prototype CO_2 dragster travels the official 20.0 m track in 1.22 s.

a) Calculate its speed in m/s.
b) Convert this speed to km/h.



- ♦ You will use a variety of different units of measurement in this course. Here's a summary.

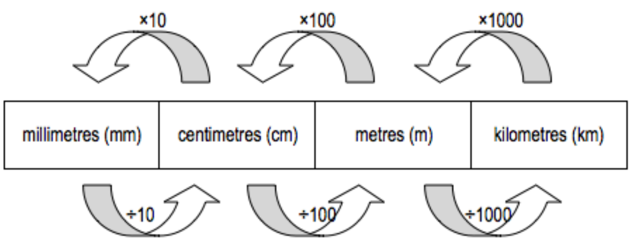
SUMMARY OF UNITS IN PHYSICS

Quantity	Unit	Symbol
distance, d	metres kilometres	m km
speed	metres per second kilometres per hour	m/s km/h
acceleration, a	metres per second squared	m/s^2
force, F	newtons	N
mass, m	kilograms	kg
time, t	seconds minutes hours	s min h

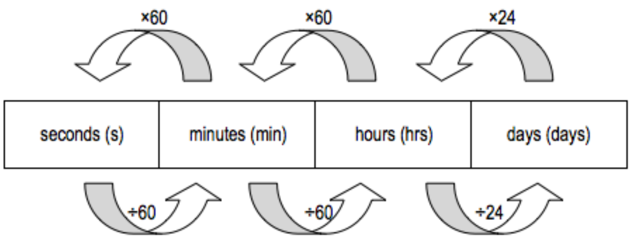
Practice Examples

Perform these unit conversions, using the conversion factors given.
Note: Scientists always *leave a space between the number and its units*.

Unit Conversion – Distance



Unit Conversion – Time

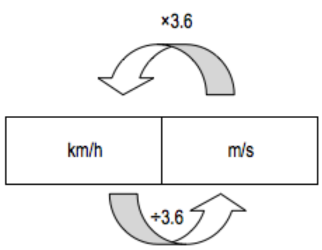


1. 30 mm = _______ cm
2. 12.43 m = _______ cm
3. 275 mm = _______ cm
4. 5 km = _______ m
5. 0.5 mm = _______ cm
6. 3.45 km = _______ m
7. 5.55 cm = _______ mm
8. 0.095 km = _______ m
9. 0.4 cm = _______ mm
10. 0.003 km = _______ m
11. 28 cm = _______ mm
12. 2900 m = _______ km
13. 300 cm = _______ m
14. 657 m = _______ km
15. 1 200 cm = _______ m
16. 8 000 m = _______ km
17. 19 cm = _______ m
18. 250 m = ________ km
19. 3.5 m = _______ cm
20. 11000 mm = _______ m
21. 0.06 m = _______ cm
22. 3.2 m = ________ mm

23. 795 ms =_________ s
24. 300 s =_________ min
25. 12 ms =_________ s
26. 45 s =_________ min
27. 2021 ms =_________ s
28. 90 s =_________ min
29. 1.25 s =_________ ms
30. 180 min =_________ hrs
31. 0.46 s =_________ ms
32. 45 min =_________ hrs
33. 0.02 s =_________ ms
34. 56 min =_________ hrs
35. 18 min =_________ s
36. 3 min + 4 s = _____________ s
37. 2 min =_________ s
38. 5 min + 28 s = ____________ s
39. 2.25 min = _________ s
40. 18 days =_________ hrs

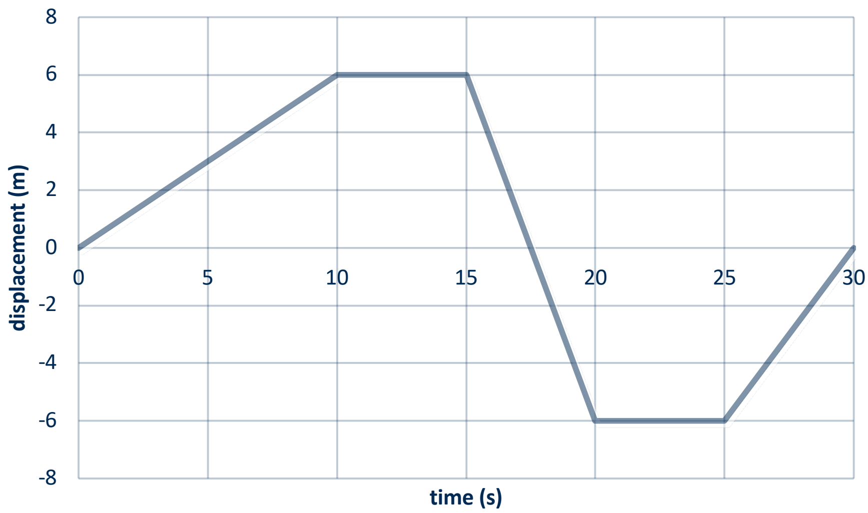
60 km/h = ____________ m/s
100 km/h = ____________ m/s
40 km/h = ____________ m/s
300 m/s = _______________ km/h
1.8 m/s =_________ km/h
20 m/s =_________ km/h

Unit Conversion – Speed/Velocity



Displacement-Time Graphs

- A displacement-time graph plots how the position of an object changes over time.
- The simplest graphs only show movement back and forth along a straight line; e.g. forward and back, up and down, left and right, north and south, east and west.



<u>Tip</u>: Interpret each straight-line segment of the graph in turn.

Gradient (Slope): ____________________

Horizontal line: ____________________

Points touching x-axis: ____________________

Positive slope above x-axis: ____________________

Negative slope above x-axis: ____________________

Negative slope below x-axis: ____________________

Positive slope below the x-axis: ____________________

Exercise

Describe the motion of the object shown by the above graph. Assume it's initial motion is east. What is the object's final **displacement**? What **distance** did the object travel?

____

____

____

____

____

____

____

Velocity

Flashcard Vocab: displace, rate, velocity

- Like speed, **velocity** measures how fast something is moving. But velocity is a **vector**, which means it takes direction into account.
  - Speed is the rate of change of distance; but
  - **Velocity is the rate of change of displacement**.
- It tells us by how much an object is being **displaced** per unit of time.
  - As for speed, the standard units are **metres per second** (**m/s**), and we also use km/h.
  - A **direction** must be included to property describe a velocity.
- Average velocity is found by dividing the displacement by the elapsed time.

$$average\ velocity = \frac{displacement}{time}$$

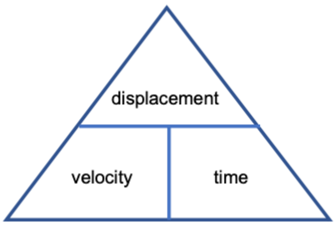
$$v_{av} = \frac{s}{t}$$

Note that "s" in a formula stands for "di**s**placement" (from a Latin word related to "space").
<u>Hint</u>: NEVER use the symbol "s" for speed! Always write the full word, "speed".

- A triangle can be used to find each quantity.

$$s = v_{av} \times t$$

$$t = \frac{s}{v_{av}}$$



- <u>Note</u>: For an object moving in a straight line in one direction, the calculations for speed and velocity will give the exact same answer, except that velocity includes the direction of travel.

In your own words, explain the difference between **speed** and **velocity**.

Worked Examples

1. What is the average velocity of a Formula 1 racing car that travels 250 m north in 2.3 s?

2. A car moves 40 km north in 20 minutes. What was its average velocity in km/h?

3. How far could Mrs Smith sprint in 2 min if her average velocity is 7 m/s?

4. Determine the displacement travelled by a Blackbird jet fighter plane in 1 hour if it flies due south with a uniform velocity of 830 m/s.

5. How long would it take for Ian Thorpe to swim a 400 m race if he can swim at 1.81 m/s?

Activity: Dice Walk (optional)

Follow your teacher's instructions for this activity, using the worksheet provided.

Exercise Set III

Collect the review worksheet, complete it, and mark your work using the answers provided.

Worksheet: "Velocity"

Lab: Using a motion sensor (cf. O10.p223)

Follow your teacher's instructions and the steps on the lab sheet.

Acceleration

Flashcard Vocab: accelerating, acceleration, acceleration due to gravity, constant velocity, decelerating, final velocity, free fall, “g-force”, initial velocity, terminal velocity

Demo: Fan cart acceleration (with video analysis of motion)

Describe the motion of the cart.

____

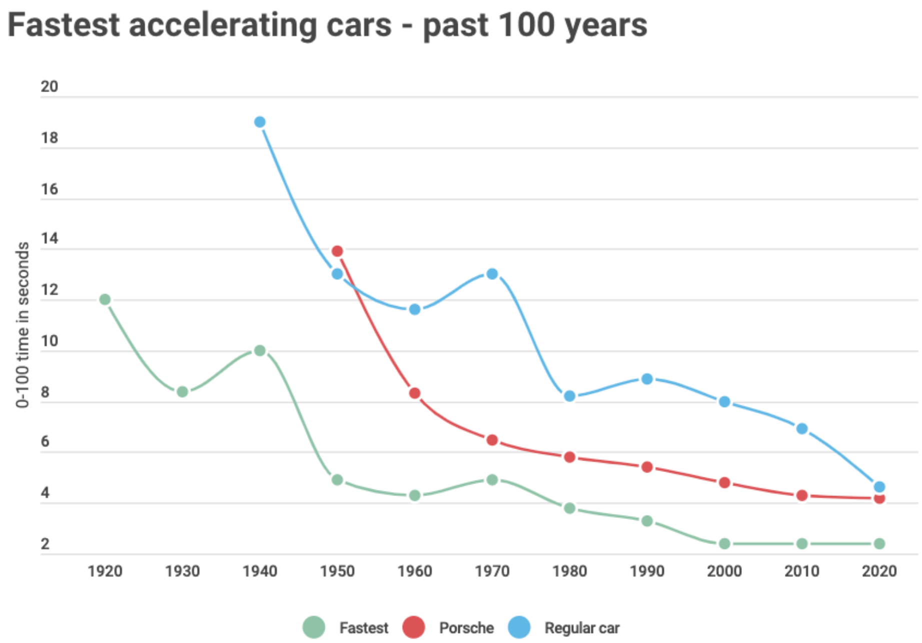
What is happening to the amount of displacement each second?

____

Sketch a simple displacement-time graph of the cart’s *acceleration*.

Activity: How fast is your car?

The graph plots the time it takes cars to accelerate from 0 to 100 km/h for the past 100 years.



Why are the fastest cars plotted near the bottom?

____

What is the general trend over the decades? ______________________________________

Estimate how quickly you think your family car could accelerate from 0 to 100 km/h! __________

- **Acceleration** is speeding up or slowing down.
  - Acceleration measures how quickly an object's speed (or velocity) changes.
  - E.g. the car in the example is increasing its speed by 12 km/h every second:

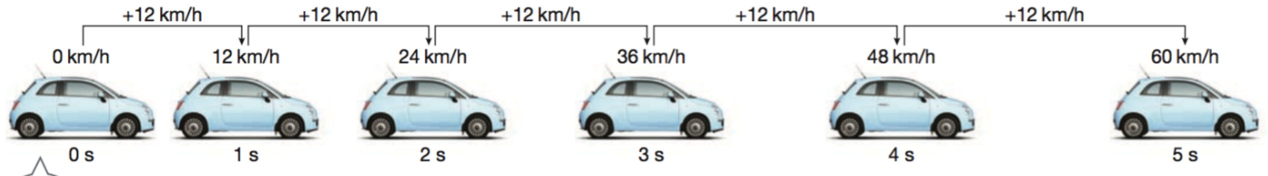


Figure 8.2.1 This car has constant acceleration. Its speed has increased by 12 km/h every second.

- **Acceleration** is defined as **the rate of change of velocity** of an object.
  - The word "rate" means per unit of time, how quickly something changes over time.
  - Like velocity, acceleration is a **vector**, so it must have magnitude and **direction**.
- To calculate acceleration, we need to know the change in speed We use these symbols:
  - u = initial velocity (starting speed)
  - v = final velocity (finishing speed)

Hint: Write "curly v" and "curly u" so that you don't get the letters mixed up!

- Change in velocity will always be the final velocity minus the initial velocity, $v - u$.
- To find out how quickly velocity changes, i.e. the rate of change, we just divide by time, so:

$$a = \frac{v - u}{t}$$ where a is the letter we use for acceleration.

  - Because we are dividing a change in velocity (m/s) by a time (s), the units of measurement are **metres per second per second**, which is $\frac{\text{m/s}}{\text{s}}$ = m/s/s or just **m/s²**.
- Acceleration can be positive, negative, or zero:
  - **positive** acceleration means "speeding up", or **accelerating**;
  - **negative** acceleration means "slowing down", or **decelerating**; and
  - **zero** acceleration means the object has a **constant velocity**.

Worked Examples

1. A Nissan 300ZX can produce an average acceleration of nearly 20 m/s^2. Explain what this acceleration means.

2. While accelerating, an object changes its velocity from 24.48 m/s to 54.00 m/s over a time period of 10.15 s. What is the value of this acceleration?

3. A powerful race car accelerates from rest to 36 m/s in 6.5 seconds. Find the average acceleration of the car.

Practice Examples

1. A train moving at 15.0 m/s speeds up to 35.0 m/s over a period of exactly one minute. Calculate its acceleration.

2. A skydiver is falling with a velocity of 60.0 m/s when her parachute opens. Her velocity 3.50 seconds later is 18.0 m/s. What acceleration did she experience?

3. A car, starting from rest, reaches a speed of 45 m/s in 8 seconds.
What was its acceleration?

4. A drag car can accelerate from rest to 180 km/h in 8.00 seconds.
   a) What was its final velocity in m/s?
   b) What acceleration does it experience?

> Hint: To get acceleration in m/s^2, velocity must be in m/s (*not* km/h).

- We can turn the acceleration formula around to give us final velocity:

$$v = u + at$$

Worked Example

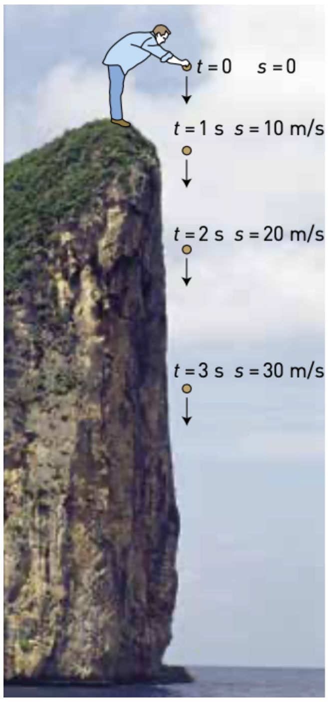
An object is travelling along with a velocity of 2.44 m/s when it accelerates at 1.97 m/s^2 for a time period of 7.47 s. What is the final velocity of this object?

Practice Examples

1. A motorcyclist riding at 14.0 m/s accelerates at 3·50 m/s^2 for 7.00 seconds.
   a) What is her final velocity?
   b) Has she exceeded the 100 km/h speed limit?

2. A racing car can accelerate at 8.00 m/s^2 during a short race.
   What final velocity did it attain in a sprint lasting 6·55 seconds?

Acceleration due to gravity



- If a stationary rock gets dropped from a height, it will steadily gain velocity as it falls.
- Each second, it gains about 10 m/s (see diagram).
- If we ignore friction, its acceleration is constant and it will get faster and faster until it hits the ground. In reality, air resistance will slow it's rate of acceleration until it reaches its **terminal velocity**, the highest speed it will reach in free fall.
- The acceleration of falling objects is caused by the force of **gravity**.
- On Earth, the **acceleration due to gravity** is g = 9.80 m/s^2.
- Note: All falling objects accelerate towards the ground (down) at the same rate, regardless of their mass (strictly true only in a vacuum).

Watch: "Falling feather in a vacuum"

Worked Example

If a penny is dropped from the Empire State Building, which is 381 m tall, with what speed would it strike the ground if it takes 8.82 s to fall? (Ignore the effects of air resistance.)

Since gravity accelerates all masses at the same rate, we don't need to know the coin's mass. Use "g" instead of a in the formula for calculating final velocity:

$$v = u + gt =$$

Practice Example

If a 2.00 kg brick is dropped off the edge of a high cliff, what is its speed 2.5 s later (ignoring friction)?

Demo: Acceleration down the slope (motion sensor)

Describe the effects of (i) the angle of the slope; and (ii) friction on the rate of acceleration down the slope of the cart.

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Lab: Measuring g-ball acceleration (cf. O10.p223)

Follow your teacher's instructions and the steps on the lab sheet.

Exercise Set IV: Acceleration

Collect the review worksheet, complete it, and mark your work using the answers provided.

Worksheet: "Acceleration"

Reaction Time

Flashcard Vocab: 2-second rule, braking distance, braking time, reaction time, reaction distance, safe following distance, stopping distance

Activity: Recording reaction times

Visit **https://humanbenchmark.com/tests/reactiontime** and test your reaction time.
Record your best time below, and convert it to seconds (÷1000).

Best reaction time (red → green): in milliseconds: ___________
in seconds: ___________

What was your best time? What factors might affect your times?

____

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- When driving a car, it takes a fraction of a second or longer to react to a hazard. The longer the reaction time, the longer it will take for the vehicle to stop.
- **Reaction time** is how long it takes a driver to start braking.

♦ A driver's reaction time can be increased by:

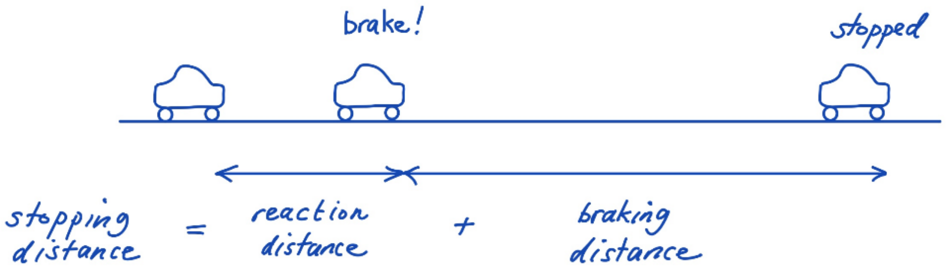
- distractions, such as mobile phone, changing music, conversation;
- influence of alcohol/drugs;
- driving conditions e.g. heavy rain, fog, day/night; and
- age and experience.

♦ **Reaction distance** is how far the vehicle travels before the driver starts braking.

♦ **Braking distance** is how far the vehicle travels during braking to come to a complete stop.

♦ The total **stopping distance** is given by:

stopping distance = reaction distance + braking distance



♦ **Safe following distance** takes reaction time into account.

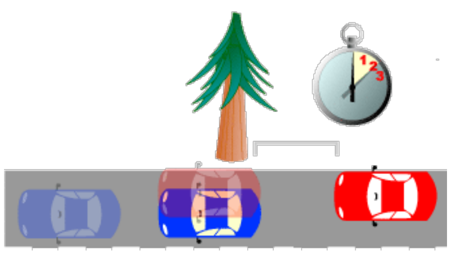
♦ Recent research showed that **nearly 28.3 per cent of WA car crashes** between July 2016 to June 2017 were **due to nose-to-tail driving** (tailgating), which usually ended up in a nasty rear-end collision. *Many motorists drive dangerously close to the vehicle in front.*

- *A motorist is usually at fault if they are involved in a rear-end accident!*
- In normal driving conditions, drivers should **leave a 2-second gap** behind the vehicle in front. This is called the **2-second rule**.

Watch: "Following distance" (Road Safety Commission)

To calculate reaction distance, we can use

$s = ut_R$ where t_R = **reaction time**



To calculate braking distance (displacement), we can use:

$s = \frac{1}{2}ut_B$ where t_B = **braking time**

Note: This rule is only true if the vehicle comes to a complete stop.

Worked Examples

1. If a person's average reaction time to apply brakes when a car pulls out in front of them is 0.4 s, determine the *reaction distance* if the car was initially travelling at:

   a) 60 km/h;

   b) 100 km/h.

Hint: Must convert km/h to m/s to get distances in m!

   Express your answers in car lengths (1 car length = 4.5 m).

2. A car is cruising at 72 km/h.

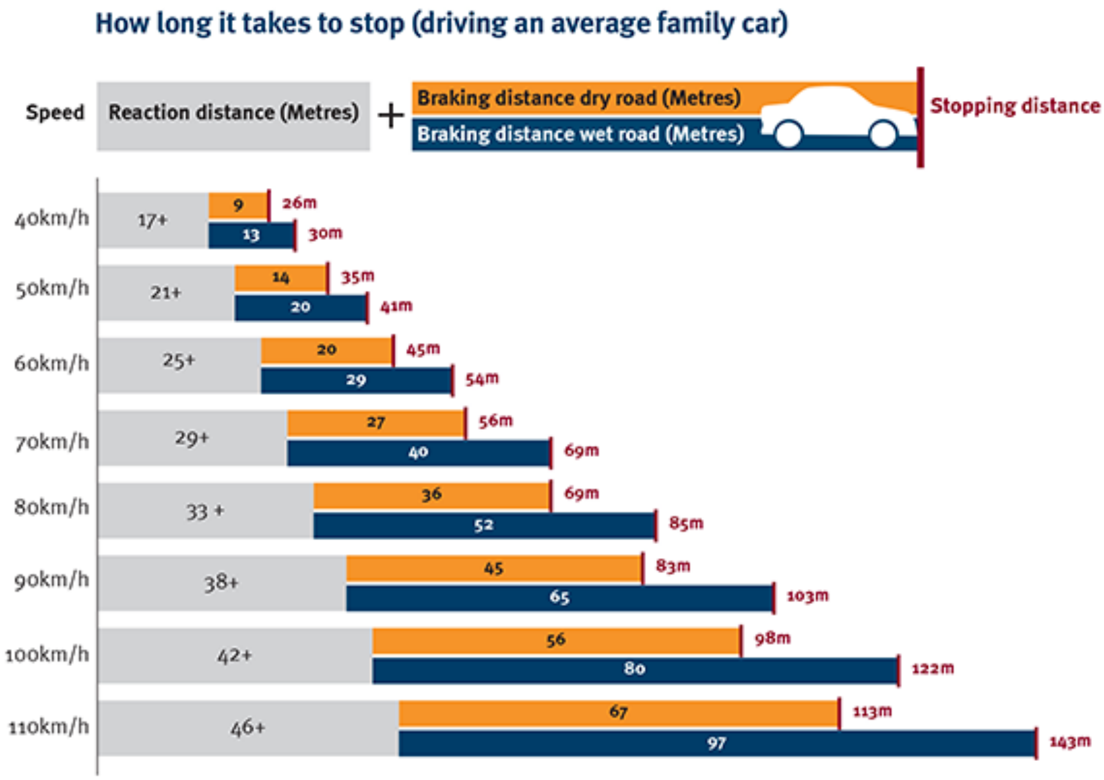
   a) How far will it travel when braking from this speed if it takes 5 s to stop?

   b) What is this distance called? ___________________________

3. Calculate the stopping distance of a family car initially travelling at 100 km/h where the driver takes 1.5 s to react and brakes for 4.5 s in order to stop.

Activity: Hit and miss

The average driver takes 1.5 s to react and the average family car can decelerate at 7.6 m/s^2.



Study the infographic and use your knowledge of how to calculate stopping distance to answer the following questions. *(Answer in your exercise book.)*

1. Suggest why stopping distance is always greater in wet weather.
2. On a rainy day, a child walks out in front of a car in a school zone (40 km/h speed limit). How much road would a driver need between the car and the child to avoid colliding if they were travelling at:
   a. 40 km/h?
   b. 60 km/h?
   c. 70 km/h?
3. Explain why sticking to the speed limit in built up areas is important.
4. Approximately how many car lengths is an average driver's reaction distance at 80 km/h? At 100 km/h?
5. Why is tailgating responsible for so many crashes? What should drivers do to minimise the risk?
6. Calculate the stopping distance of a truck travelling at 110 km/h when the driver takes 1.2 s to react and the truck comes to a stop after 5.5 s of braking.

Revision Set: Mid-Topic Test

Collect the revision worksheet, complete it, and mark your work using the answers provided.

Worksheet: “Physics Mid-Topic Test Revision”

Force

Flashcard Vocab: contact force, force, net force, non-contact force

Demo: May the force be with you (P10.2nd.p384)

May the force be with you

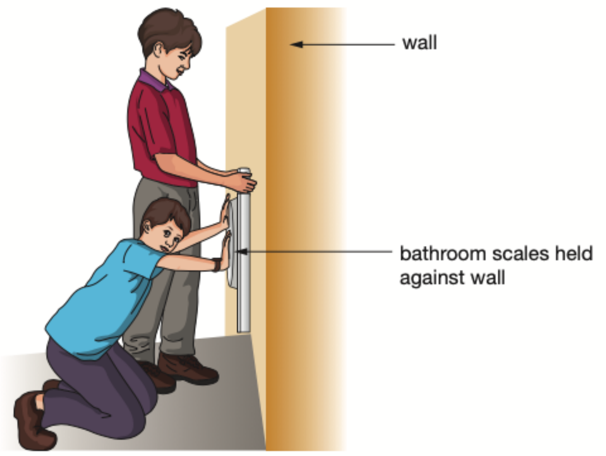
How hard can you push?
Who in your class has the most force?

Collect this …

- an old set of bathroom scales

Do this …

1. Have a classmate hold an old set of bathroom scales against a wall
2. Push as hard as you can against the scales with one hand
3. Record the number of kilograms the scale reaches when you push
4. Multiply this number by 10 to calculate the size of your pushing force in newtons.
5. What is your class record?



Record this …

1. Describe what happened when you pushed on the scales.
2. Explain why you think this happened.

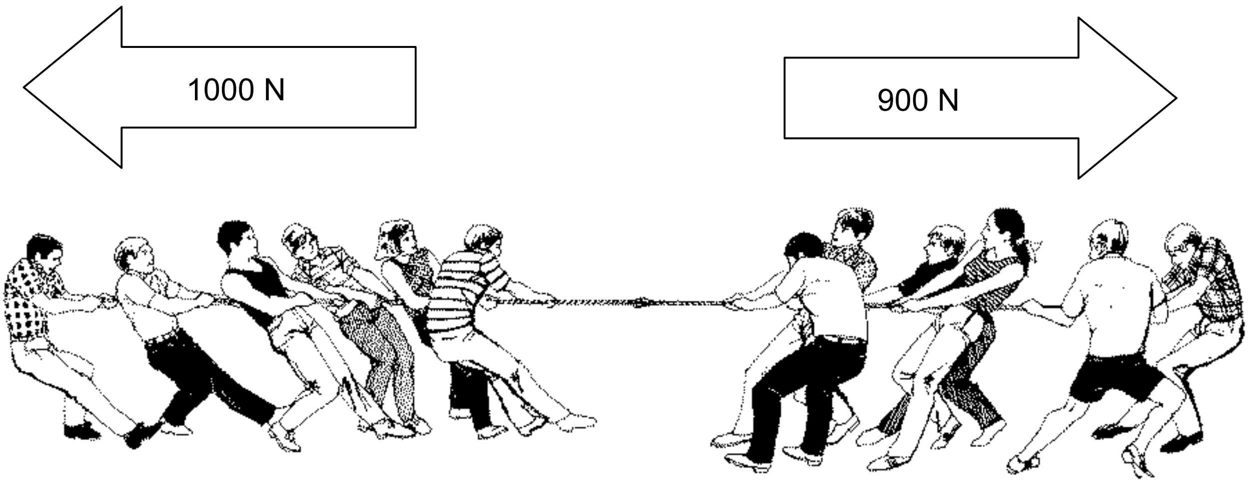
- A **force** is a **push** or pull in a particular direction.
  - Forces are **vectors**, because they have direction, and are measured in **newtons** (**N**).
  - Forces are either **contact** (e.g. objects pushing each other, hitting, collisions) or **non-contact**, able to act from a distance (e.g. gravity, magnetism).
    - ◊ A force itself cannot be seen, but we can observe and measure its effects.
    - ◊ Non-contact forces are imagined to act through **fields**, such as a gravitational field.

- More than one force can act on an object at a time, and in any direction. What happens depends on: (i) how strong the forces are; and (ii) their direction.
- Like all vectors, forces may be represented by **vector arrows** which indicate the magnitude (size) of the force, and the direction of the force (e.g. compass bearings, up, down, left or right; right angles to a surface).
- Just like we saw with displacement, **force vectors can be added** to find the **resultant**, which is usually called the **net force**, acting on an object.
  - The **net force** is the combination of all the forces acting on an object.

- **Unbalanced forces** don't cancel each other out. They can cause a mass to start moving, stop moving, speed up, slow down, change direction, or change shape.
  - In general, **unbalanced forces cause acceleration**.
- **Balanced forces** are those that cancel out and have no effect.
  - If two forces of equal strength act on an object in opposite directions, the forces will cancel, resulting in a net force of zero and no change in motion.

Exercise

Circle the best answer:



1. The forces shown above are **PUSHING / PULLING** forces.
2. The forces shown above are **WORKING TOGETHER / OPPOSITE FORCES**.
3. The forces are **EQUAL / NOT EQUAL**.
4. The forces **DO / DO NOT** balance each other.
5. The resultant force is **100 N TO THE RIGHT / 100 N TO THE LEFT / ZERO**.
6. There **IS / IS NO** motion.

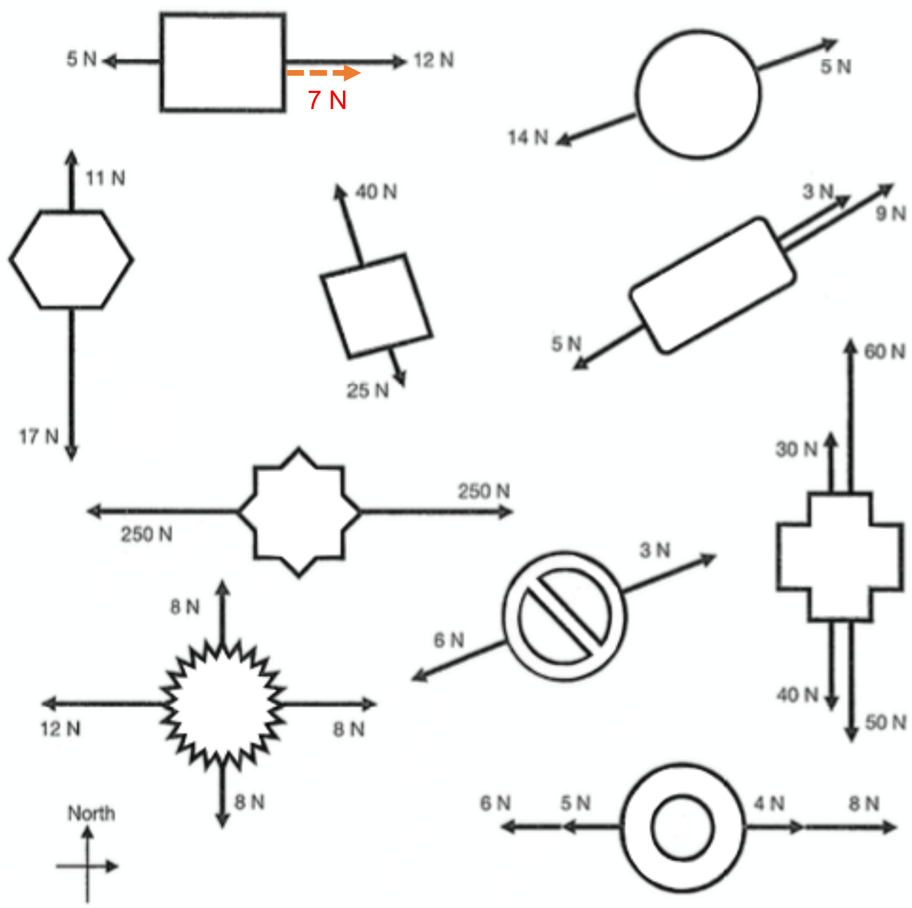
- **Free body diagrams** show all the forces acting on a single object.

Exercise

The free body diagrams below show different forces acting on a variety of objects. In this exercise, each object is *resting* (i.e., is stationary) on a horizontal, frictionless surface.

- When forces act in the same direction on an object, the size of the net force is equal to the **sum** of the two forces (**add** the numbers).
- When unequal forces act in opposite directions on an object, the size of the net force is the **difference** of the two forces (**subtract** the numbers).

Calculate the net force acting on each object, and draw a resultant vector with a ruler to show the net force, if any. The first one has been done for you. (Note: Not drawn to scale.)



Newton's First Law

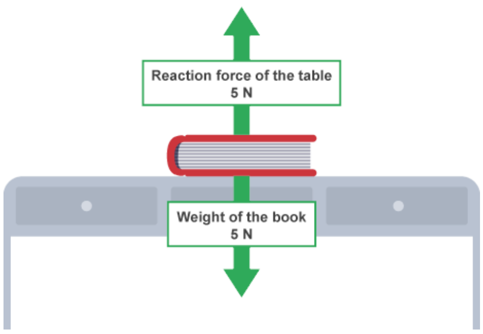
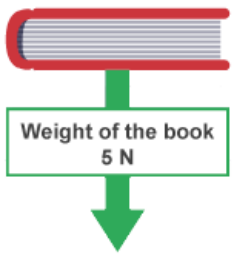
Flashcard Vocab: drag, friction, inertia, lift, Newton's first law, Newton's laws of motion, reaction force, retarding force, sliding friction, static friction, thrust, weight force

- How forces cause changes in motion is described by **Newton's laws of motion**.

Demo: Air track – inertia and effect of friction

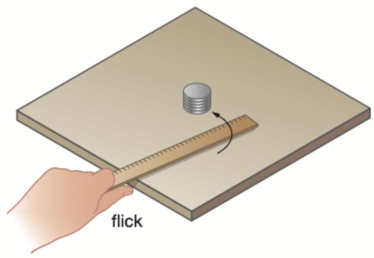
How would the motion of the cart on the air track when it is *off* compare with when it is *on*? What causes the difference? How does this demonstrate the idea of **inertia**?

Safety!
Sliding a cart when the air track is off will damage the track.

<table>
<tr><td>1st Law (inertia)</td><td>An object remains at rest, or moving at a constant velocity, unless acted upon by an unbalanced, external force.</td></tr>
<tr><td colspan="2">This means that only an unbalanced force can cause an object's motion to change.</td></tr>
<tr><td>When at rest on a table, a book has a weight force pulling it down, and a reaction force from the table pushing it up. These two forces are equal in size and cancel. Since the forces are balanced, the net force is zero and there is no change in motion.
Because the net force is zero, the book's inertia keeps it stationary.</td><td>Without the table, the book only has its weight force pulling it down, an unbalanced net force. Therefore, it will accelerate down.</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Demo: Loose change (P10.p269)

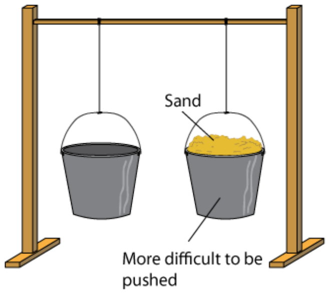
Use the concept of inertia and your understanding of forces to explain your observations.



Inertia

To explain this Newton's first law, we define **inertia** as the property of mass that resists a change in motion.

The amount of inertia an object has depends on its mass. Note that **inertia is not a force!** It is possessed by all masses.

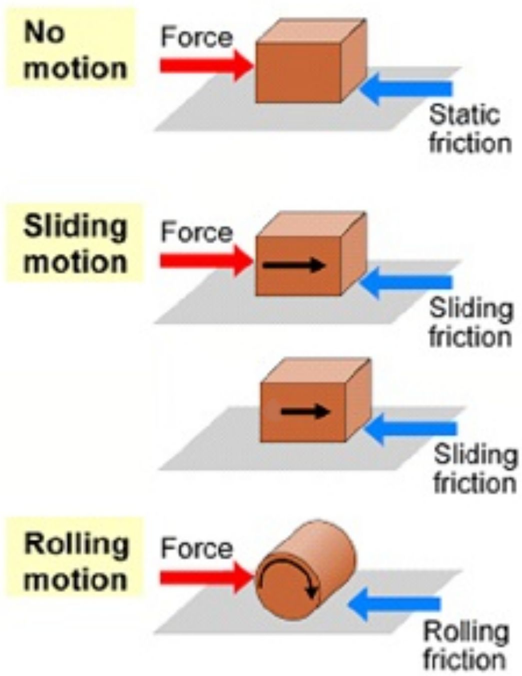


The bucket with the sand is harder to move because it has **more mass** and therefore **more inertia**.

An unbalanced force must be applied to any mass in order to **overcome its inertia** and cause it's state of motion to change.

Friction

Friction is a **force** that **opposes motion**. It acts between two surfaces in contact. It is the resistance to the motion of one object moving relative to the other.



- Pushing a box at rest sideways won't move it if the **static friction** balances the applied force. Static friction acts on stationary objects when a force is applied.
- Once the box is moving at a **constant velocity**, it will continue to move at the same speed as long as the applied force is exactly balanced by **sliding friction.** Sliding friction is always less than static friction: it is easier to keep an object moving than to start it moving.

  If the applied force is removed, then the sliding friction is the only force acting. This net **retarding force** provided by sliding friction will decelerate it until it stops.
- **Rolling friction** is less than sliding friction due to the reduced surface area. An object will continue rolling at a constant velocity if the applied force and rolling friction are equal in size and cancel so that the net force is zero.

Lab: Coin drop

Use friction and inertia to explain why pulling the card doesn't accelerate the coin sideways.

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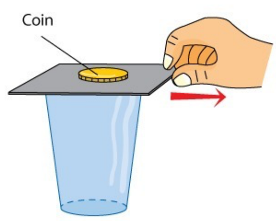
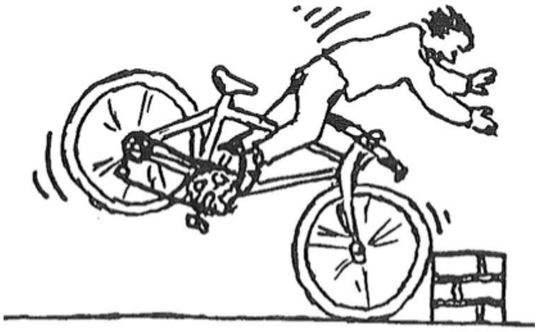
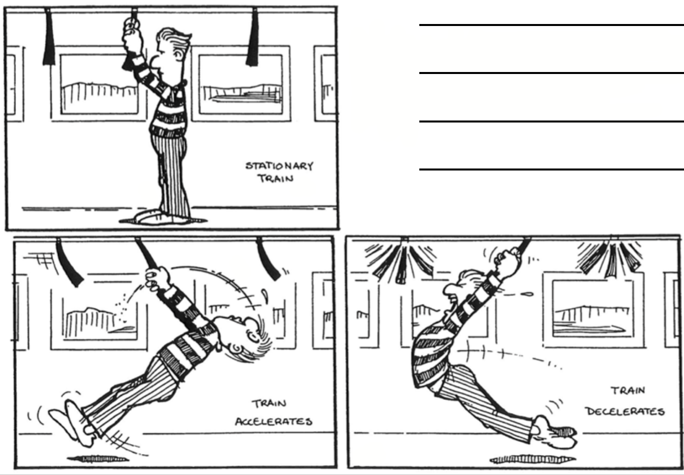


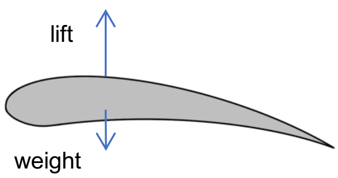
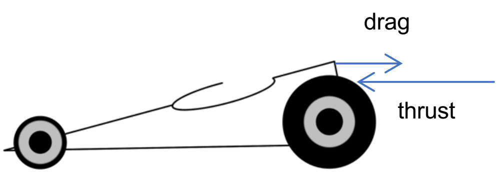
Exercise

Apply Newton’s first law to explain what is happening in these scenarios.





Other examples

• To lift off, lift must be greater than weight.	• To speed up, thrust must be greater than drag.
	

Lab: Make an accelerometer (O10.p224; cf. P10.p267)

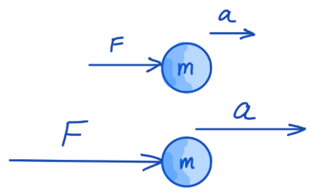
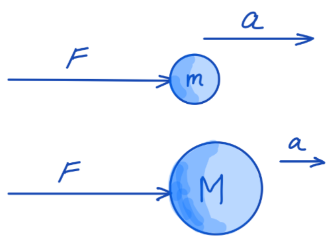
Follow your teacher’s instructions and the steps on the lab sheet.

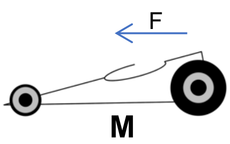
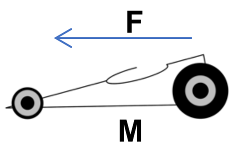
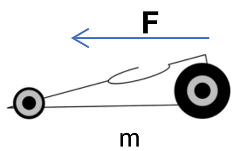
Newton's Second Law

Flashcard Vocab: Newton's second law

- **Newton's second** law describes the relationship between force and acceleration.

Watch: "CO2 Dragster Championships 2020" (YouTube)

2[nd] Law	***If an object is subjected to an unbalanced, external force, the acceleration experienced in the direction of the force is (i) inversely proportional to its mass and (ii) proportional to the force.***
This means that: (i) a force can accelerate lighter objects at a greater rate than heavier objects; and (ii) a larger force produces greater acceleration.	
	**Same mass**: • Smaller force, smaller acceleration • Large force, larger acceleration
	**Same force**: • Smaller mass, larger acceleration • Larger mass, smaller acceleration
E.g. For a dragster to have maximum acceleration, **thrust** should be the largest possible force, and **mass** should be kept low.	

		
slow	**faster**	***fastest!***

Demo: Air track – accelerating masses

In terms of Newton's second law, describe what you observed.

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Calculating force and acceleration

- The size of forces and the amount of acceleration can be calculated using:

$$F = ma \qquad \text{or} \qquad a = \frac{F}{m}$$

Worked Examples

1. How much force is needed to accelerate a 1 400 kilogram car 2 m/s^2?

2. A 2 kg object is being pulled with a 5N force to left and a 10N force to right. What is the object's acceleration?

Practice Examples

1. What force is required to accelerate a 1.2 kg trolley at 3 m/s^2?

2. What force is needed to accelerate a 10 kg bowling ball at 3 m/s^2?

3. What is the deceleration of a 0.5 kg softball if the catcher's glove applies a force of 25 N?

4. What is the force of impact on a 3 000 kg truck if hitting a tree causes it to decelerate at a rate of 2 m/s^2?

5. What force is needed to accelerate a mass of 8 kg from rest to a velocity of 25 m/s in 5 s? [Hint: Calculate the acceleration first!]

Interactive: PhET Forces and Motion Basics

Visit **https://phet.colorado.edu/en/simulation/forces-and-motion-basics** and explore the relationship between mass and acceleration.

Lab: Newton's second law (P10.p277)

Follow your teacher's instructions and the steps on the lab sheet.

Exercise Set V: Forces 1

Collect the review worksheet, complete it, and mark your work using the answers provided.

Worksheet: "Forces 1"

Task: Car crash safety investigation

Follow your teacher's instructions to begin **planning** your investigation.

Weight

Flashcard Vocab: acceleration due to gravity, mass, weight

♦ **Weight** is the force of gravity acting on a mass.
- We have seen that on Earth, the acceleration due to gravity is: g = 9.80 m/s^2.
- Newton's second law can be tweaked to calculate weight using g for the acceleration:

$F = ma$ becomes: $W = mg$ where W = weight force

♦ Mass and weight are not the same:

mass	**weight** – is a force
• the **amount of matter** an object contains	• the **force of gravity** acting on an object
• measured in **kilograms** (kg)	• measured in **newtons** (N)
• a **scalar** quantity	• a **vector** quantity (direction = **down**)
• **constant** everywhere in the universe	• **changes** in the universe

♦ A persons' weight depends on the gravitational force they are experiencing.

Activity: Weights in the Solar System

The table shows the gravitational field strength in various places in our Solar System.

Space object	**g**
The Sun (star)	293.0
Mercury	3.7
Venus	8.8
Earth	9.8
Moon (satellite)	1.7
Mars	3.7
Ceres (dwarf planet)	0.27
Jupiter	24.7
Saturn	10.5
Uranus	9.0
Neptune	11.7
Pluto (dwarf planet)	0.49

Worked Example

An apple has a mass of 100 g. Calculate its weight on Mars.

Practice Example

1. Compare the (i) mass; and (ii) weight of a 90 kg man on Earth and on the Moon.

FACT: An astronaut orbiting Earth feels *weightless* because they are falling around the planet, not because there's no gravity!

Newton's Third Law

Flashcard Vocab: action force, action-reaction pair, Newton's third law, reaction force

Demo: Water bottle rocket launches (mass dependent)

How did changing the amount of water in the bottle affect its flight?

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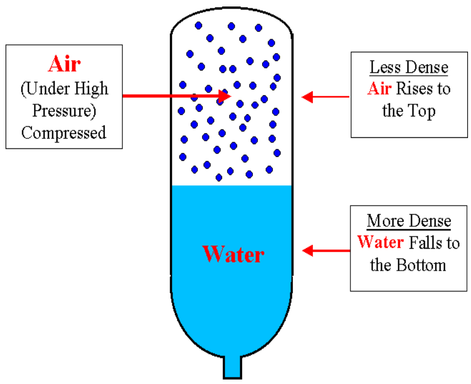


Why does the bottle rocket shoot upwards?

- The pressurised air and water mixture pushes against the bottle equally in every direction. When the pressure reaches a critical level, it pops the "cork" out of the nozzle and the pressurised air and water is expelled.

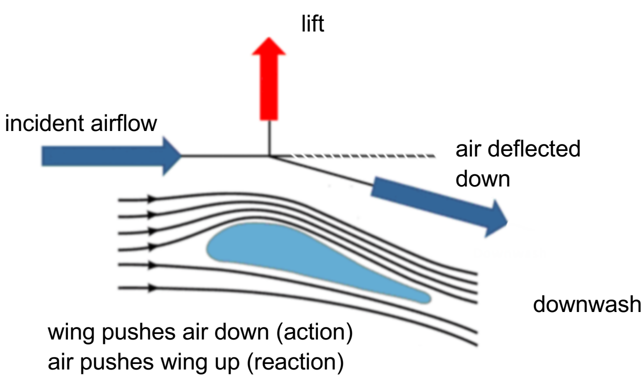
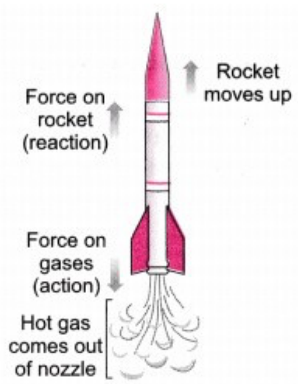
The upward force of thrust is great enough to overcome the downward forces of weight and air resistance.

- The forces against the sides cancel out, but there is an unbalanced force pushing upwards once the nozzle is open. This unbalanced force creates the thrust.

- Newton's third law explains that as the air-water mixture pushes the bottle upwards, the bottle pushes the air-water mixture downwards with an equal and opposite force.

3rd Law	***For every action force there is an equal and opposite reaction force, and these forces act on different objects.***

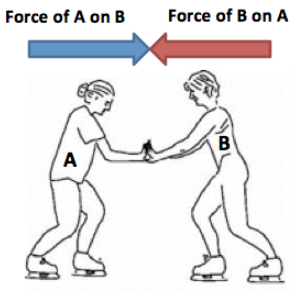
This means: **forces always act in pairs**, **in opposite directions**, and on **different objects**. Each pair of forces is known as an **action-reaction pair**.

• As the wing pushes air down (action), the air pushes the wing and plane up (reaction), creating lift.	• As expanding gases are pushed out of the pressure chamber (action), the gases push the vehicle forward (reaction).
	

♦ The table below gives examples of action-reaction pairs:

Action Force	Reaction Force
A nail is hit by a hammer.	The nail exerts an equal force back on the hammer.
A sprinter pushes back on the starting blocks as a race begins.	The starting blocks push forward on the sprinter.
A book resting on a table exerts its weight force onto the table.	The table exerts an equal reaction force upwards on the book.
An octopus squirts water out as jets through a tube just below its head.	These water jets push back on the octopus, propelling it in the opposite direction.
You stand on a skateboard and push against a wall.	The wall pushes back on you with equal force, and you move away.

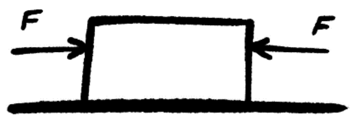
Demo: Get your skates on!

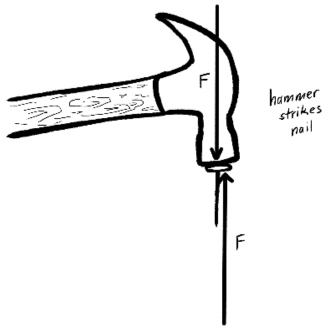
Scenario	Observation	Explanation
		

Think!

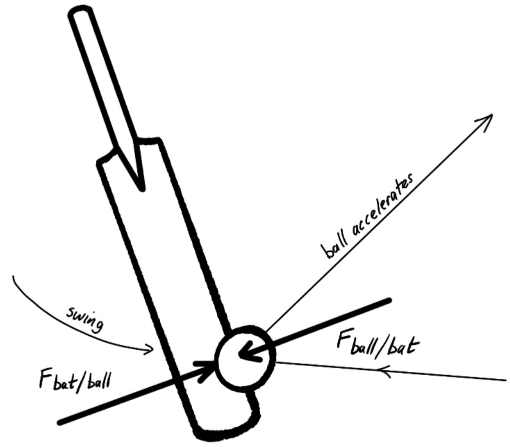
1. If action-reaction forces are always equal and opposite, then how can there ever be an unbalanced force?

What's the difference?

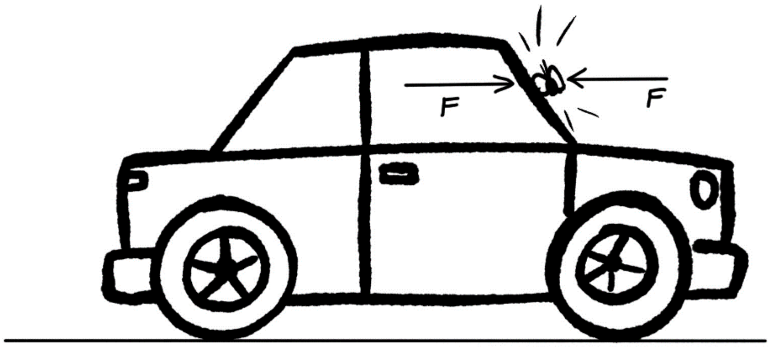




2. If colliding objects exert the same force on each other, then why isn't there equal movement?



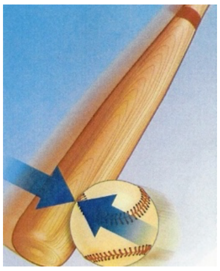
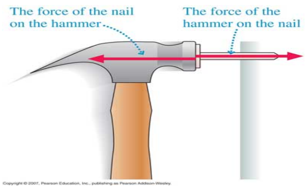
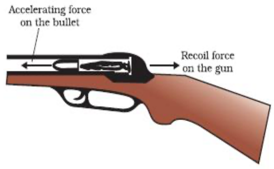
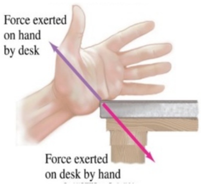
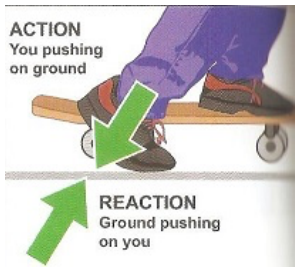
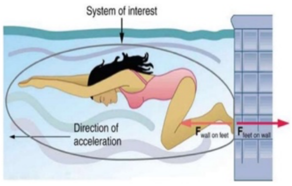
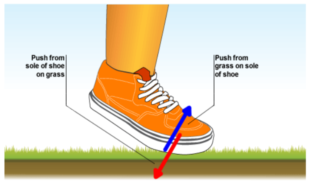
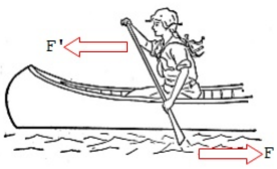
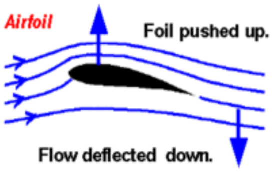
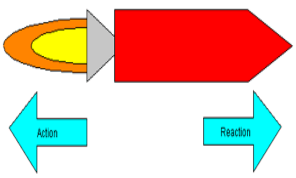
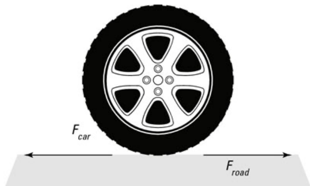
3. If forces during a collision are equal in size on both objects, then why isn't there equal damage?



Newton's Laws: Key Points

- Only an **unbalanced** force can cause a change of motion, i.e. acceleration – Newton's 1st Law
- The greater the force, the greater the acceleration – Newton's 2nd Law
- The same force will accelerate a smaller mass more than a larger mass – Newton's 2nd Law
- Newton's 3rd Law:
  - Action-reaction forces always act on **different objects**; otherwise, they would cancel out and no acceleration would be possible.
  - Action-reaction forces are always **equal in size**, but different effects are possible if each object has a different mass (amount of inertia), or other differences such as strength, softness etc.
  - Action-reaction forces always act in **opposite directions** to each other; if one object accelerates, the other will usually decelerate.
  - Forces always exist as **action-reaction pairs**, even if it's not obvious.

Exercises Explain each of these scenarios in terms of Newton's 3rd Law:

Scenario	Explanation	Scenario	Explanation
	Action force: Reaction force: Effect:		Action force: Reaction force: Effect:
	Action force: Reaction force: Effect:		Action force: Reaction force: Effect:
	Action force: Reaction force: Effect:		Action force: Reaction force: Effect:
	Action force: Reaction force: Effect:		Action force: Reaction force: Effect:
	Action force: Reaction force: Effect:		Action force: Reaction force: Effect:
	Action force: Reaction force: Effect:		Action force: Reaction force: Effect:

Exercise Set VI: Forces 2 and Physics Topic Test Revision

Collect and complete the worksheets, then mark your work using the answers provided.

Worksheet: "Forces 2"

Worksheet: "Physics Topic Test Revision"

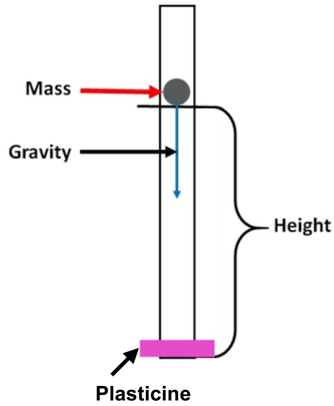
Task: Car crash safety investigation

Follow your teacher's instructions to **conduct** and **evaluate** your investigation in preparation for your **final report**.

Work and Energy

Flashcard Vocab: energy, energy transfer, energy transformation, impact force, work

Demo: Work done by a falling object



What happens if different masses, dropped from the same height, strike the Plasticine?

____

____

What happens if the same mass is dropped from different heights?

____

____

____

Explanation

- We know that an unbalanced force is able to move an object, or change its shape.
  - In the demo, the falling mass impacted the Plasticine with an unbalanced force; the greater the force, the larger the dent.
- In physics, we say that **work is done** whenever a force causes movement or rearranges matter somehow. **The larger the force, the greater the work done**.
  - In the demo, using a heavier mass or dropping the mass from a greater height increased the force of impact, and therefore the amount of work done on the Plasticine.

♦ It takes energy to generate a force. By definition, **energy is the ability to do work**.

- When work is done, energy is always transferred or transformed.
  - ◊ When energy is passed **from one object to another** we say it has been **transferred**.
  - ◊ When energy changes **from one form to another** we say it has been **transformed**.
- Energy has the same units as work because the amount of work done depends on the amount of energy transferred or transformed.
- The **standard unit** for both **work** and **energy** is the **joule** (**J**).

Exercise

1. For each of the following objects identify the energy transformation that is taking place:
   a) a toaster ______________________________
   b) a natural gas stove ______________________________
   c) a battery ______________________________
   d) a phone charger ______________________________
   e) solar panels ______________________________
2. A blender converts electrical energy to useful mechanical energy but it also produces some waste sound energy. If a blender used 3000 J of electrical energy and produced 800 J of waste sound energy, how much useful mechanical energy was produced?

   ____

♦ **Work can be calculated by multiplying the force by the distance it moves an object**:

$Work = Fd$ where *Work* is the work done
and *d* is the distance through which the force acts to cause movement

Worked Examples

1. How much work must be done to lift a 135 kg barbell 50 cm off the ground?

Lifting involves working against gravity. The average force required to lift a mass has to equal the force of gravity pulling down, i.e. the weight of the mass.

m = 135 kg
g = 9.80 m/s^2
d = 50 cm =

Weight of barbell:

$$W = mg =$$

Work done:

$$Work = Fd =$$

Watch: “2011 Volvo S60 Sedan - Frontal full width crash test” (YouTube)

2. The Volvo in the crash test was moving at 40 km/h. It had a mass of approximately 1 500 kg. The footage reveals that it stops in 66 ms over a distance of 0.37 m, which equals the amount the crumple zone shortened (crushed).
    a. Calculate the deceleration of the car when it hit the barrier.
    (Hint: Make sure you are using the correct units!)

    b. Calculate the size of the force exerted by the wall to stop the car.

    c. How much work was done by the barrier to stop the car?

    d. How much energy did the crumple zone absorb? ___________ J

    e. What happens to the energy that isn’t absorbed by the crumple zone?

____

____

    f. List other car safetly devices and materials that are designed to absorb energy.

____

____

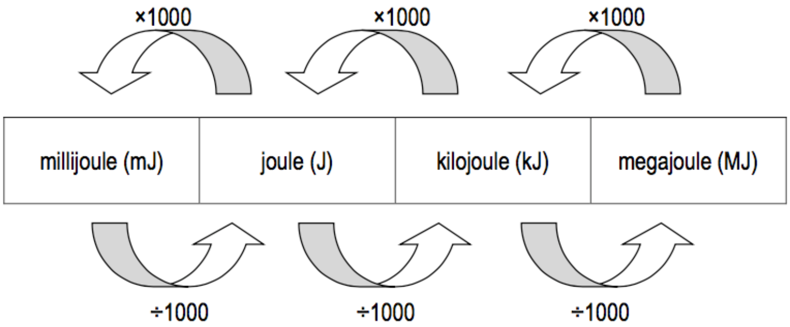
____

Energy unit conversions

- ♦ The diagram gives the conversion factors to change between common units for energy.

Example

Convert 2 800 J to kJ.



Practice Examples

1. Convert the following:

- 4.2 kJ = ________ J
- 6 880 J = ________ kJ
- 0.056 kJ = __________ J
- 5.5 kJ = ___________ J
- 3 500 J = __________ kJ

0.809 MJ = _________ J

1 400 000 J = _______ MJ

2.2 MJ = _________ kJ

0.64 MJ = ______________ J

850 000 000 J = ___________ MJ

2. How much work is done by gravity on a 0.5 kg mass that falls from a height of 0.75 m?

3. A 250 g mass strikes a layer of Plasticine and creates a dent of depth 0.5 cm.

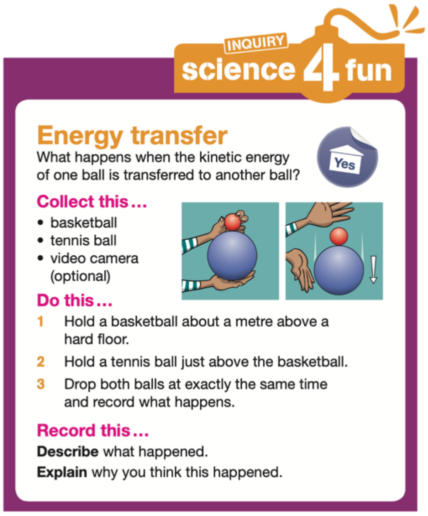
4. How much work is done by a layer of playdough to completely stop a falling bocce ball that strikes it with a force of 450 N to create a divot of depth 0.6 cm?

Kinetic Energy

Flashcard Vocab: kinetic energy

Demo: Energy transfer (P10.p280)

Why is the velocity of the smaller ball so much greater than the larger one?



- **Kinetic energy** is **energy of motion**. Any moving object has kinetic energy.
- The kinetic energy of an object in simple straight-line motion can be found using:

$$\mathrm{KE} = \frac{1}{2}mv^2$$

where KE= kinetic energy, measured in joules (J)

$m =$ mass, measured in kilograms (kg)

$v =$ velocity, measured in metres per second (m/s)

Note: All non-standard units must be first converted to the standard units shown above.

Worked Example

A CO_2 dragster can achieve an experimental top speed of 24.5 m/s. How much kinetic energy does it possess at that speed if its mass is 75 g?

$m = 75 \div 1000 = 0.075$ kg

$$\mathrm{KE} = \frac{1}{2}mv^2 = 0.5 \times 0.075 \times 24.5^2 = 2.3\ \mathrm{J}$$

Practice Examples

1. Calculate the KE of a 1.4 kg bowling ball travelling in a straight line at a speed of 6 m/s.

2. A space capsule strikes the sea with a velocity of 20 m/s. If it has a mass of 1 500 kg, what is its KE on impact with the sea?

3. A ping pong ball is hit and strikes a student on the back with a velocity of 15 m/s. If the ball has a mass of 2.7 g, with what KE does the ball strike the student?
(Hint: Convert grams to kilograms!)

Potential Energy

Flashcard Vocab: elastic potential energy, gravitational potential energy, potential energy

Activity: How much can you lift?

Visit **https://strengthlevel.com/strength-standards** Set it for your gender, and use kg. Choose an exercise and estimate how much you could lift by reading the table.

Name of my chosen exercise: ______________________

Estimated lift I could perform: ___________ kg

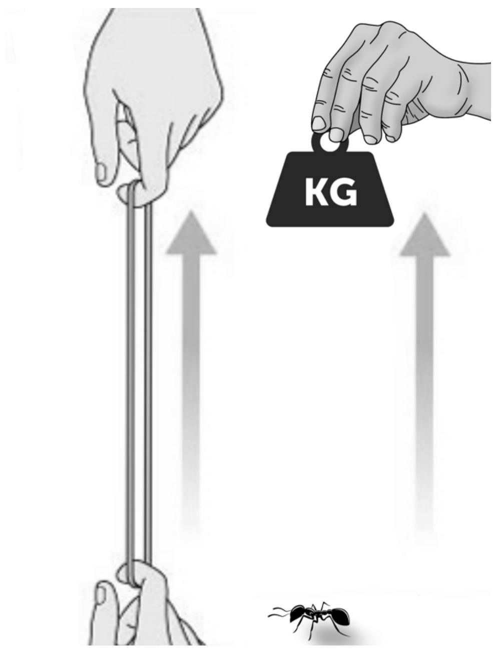
My rating for this lift (novice etc.): ______________________

Lifting weights takes energy because we are working against the force of gravity. The heavier the object, the greater the amount of energy required to raise it.

- **Potential energy** (PE) is **stored energy** which can be used to do work. Two common forms are:
  - **Elastic** PE – the energy stored within a stretched, compressed or twisted object, such as a spring or rubber band; and
  - **Gravitational PE** – the energy of an object raised above the Earth's surface.

Example

- **Stretching a band**: the **work** done on it **gives it elastic PE**.
- **Raising a mass**: the **work** done on it, **gives it gravitational PE**.
  - In both cases, this stored energy is **converted** back **into KE** when released.



Example

♦ Going up and down hills converts energy between gravitational PE and KE.

Rider has maximum PE

____

____________________.

Going uphill the rider

____

__________________.

Rider cycles downhill and

loses ________________

______________________.

Rider's PE at ground level is __________.

(Greg's cycling blog)

♦ To calculate gravitational potential energy:

$$\mathrm{PE} = mgh$$

where $\mathrm{PE} =$ potential energy, measured in joules (J)

$m =$ mass, measured in kilograms (kg)

$g =$ 9.80 m/s^2 on Earth

$h =$ height above the ground (m)

<u>Note</u>: All non-standard units must be first converted to the standard units shown above.

♦ The amount of PE depends on height above ground and mass:

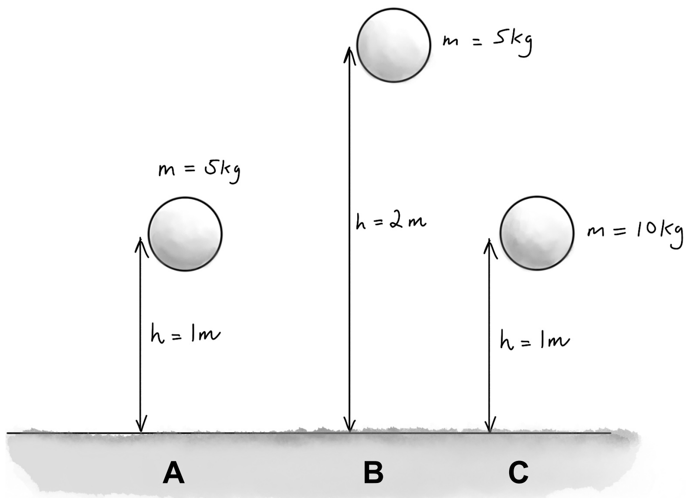
- An object raised **higher** stores **more gravitational PE**.
- An object with **greater mass** stores **more gravitational PE**.

<u>Example</u>:

✓ Ball B has twice as much PE as ball A because it is __________ as high.

✓ Ball C has twice as much PE as ball A because it has twice the ________.

✓ So balls B and C have the ________ amount of GPE as each other.



Worked Example

1. How much gravitational potential energy (PE) does a 135 kg barbell gain when it is lifted 50 cm off the ground? How does this compare to the amount of work done in lifting it?

Practice Examples

1. A rocket of mass 25 kg reaches a height of 500 m before beginning its fall back to earth. What is its maximum potential energy (PE)?

2. An athlete of mass 60 kg jumps vertically upward such that her centre of gravity is lifted to a position 56 cm above the ground. What is her PE at her highest point above the ground?

3. A hoist is a car service centre lifts a one tonne car to a height of 1.2 m above the ground. How much energy was expended by the hoist? [Note: 1 t = 1 tonne = 1 000 kg]

Exercise Set VII: Energy

Collect the review worksheet, complete it, and mark your work using the answers provided.

Worksheet: "Energy"

Conservation of Energy

Flashcard Vocab: bob, Law of Conservation of Energy, pendulum, surroundings, system

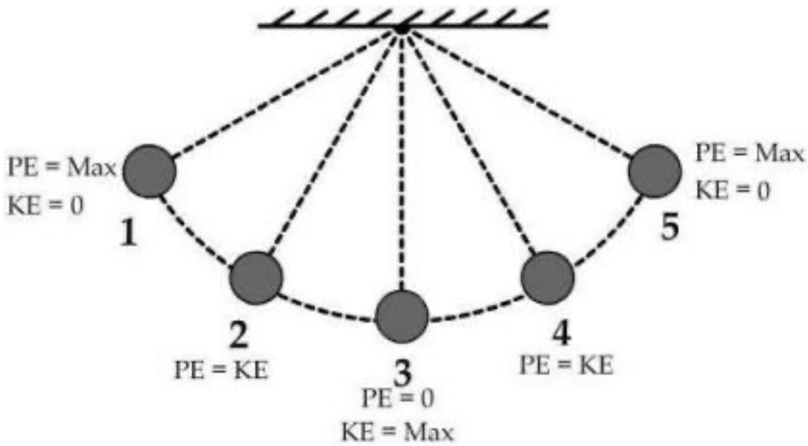
Demo: Big pendulum

Explain why it is safe to let a massive pendulum go from just in front of the face and allow it to swing back towards you.

- The **Law of Conservation of Energy** states that **energy cannot be created or destroyed**.
  - This means that during energy transformations, the **total energy remains constant**.
  - Energy lost from the **system** is actually just being transferred to the **surroundings** in wasted forms such as heat, sound etc.
- If no energy is ever lost, a pendulum would keep swinging forever! Energy is simply being converted back and forth between gravitational PE and KE.

Exercise: Energy changes in a pendulum

Many types of motion are like a pendulum swing. The diagram shows the energy changes.



1. How do we know that kinetic energy at the top of the swing is zero?

---

2. What energy transformation takes place (i) on the way down? (ii) on the way up?

---

3. Suppose the maximum PE of a pendulum **bob** (the mass) is 2 joules. Assuming no energy is lost to the surroundings, how much KE will the bob have at the bottom of its swing?

Interactive: Energy Skate Park Basics (PhET)

Visit **https://phet.colorado.edu/sims/html/energy-skate-park-basics/latest/energy-skate-park-basics_en.html** and explore energy conservation in a skate park.

Test the effect of changing masses, heights, and adding friction. Write a summary below.

Lab: Energy changes in a roller coaster (cf. P10.p286)

Follow your teacher's instructions and the steps on the lab sheet.

Energy loss and efficiency

Flashcard Vocab: efficiency, energy converter, energy efficient, inefficient, useful energy output

- **Energy converters** are never 100% efficient because some energy is always wasted, usually as heat.
- An **energy efficient** device, or machine, has a high proportion of **useful energy output**. If a lot of the **total energy input** is wasted, then the device is said to be **inefficient**.
- Reducing **friction** increases energy efficiency by preventing energy being lost as heat, sound, an unwanted vibrations that cause wear.
  - E.g. A more energy efficient car body will:
    - ◊ minimise aerodynamic drag; and
    - ◊ minimise friction in the motion of the wheels, bearings and axles.
- Efficiency is usually calculated to be the percentage of useful energy transformed using the formula:

$$\%\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

Note that the bigger number will always be on the bottom!

Worked Example

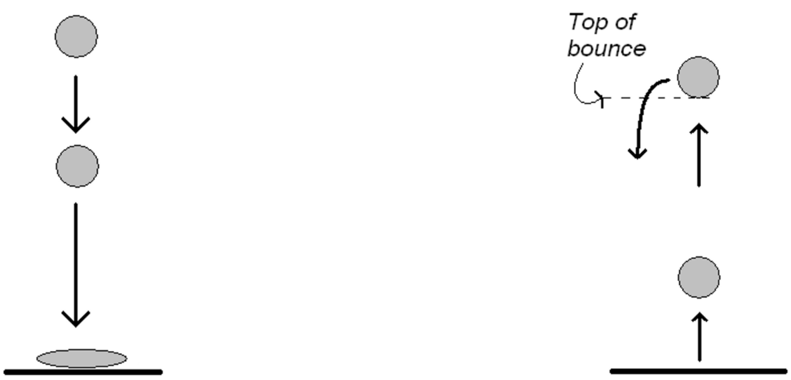
Calculate the efficiency of a petrol engine that transforms 1000 J of chemical potential energy into 300 J of kinetic energy, and 700 J into wasted heat and sound energy.

Practice Example

Calculate the efficiency of an electric motor that transforms 1000 J of chemical potential energy into 975 J of kinetic energy, and 25 J of wasted heat and sound energy.

Activity: Efficiency of bouncing balls

Explain the energy changes that occur as a ball bounces but is unable to return to its original height.



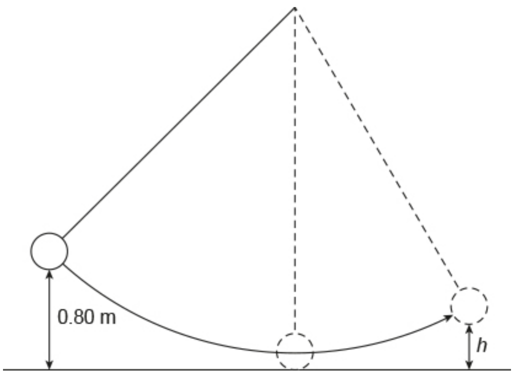
Worked Example

Determine the efficiency of a tennis ball that was dropped 5 times from a height of 200 cm.

	Height the ball bounced to (cm)					
Height the ball was dropped from (cm)	repeat 1	repeat 2	repeat 3	repeat 4	repeat 5	Average of all repeats
200	105	103	109	104	106	105.4

Challenge!

If the pendulum has an efficiency of 95% on each swing, to what height will the bob rise after a single swing if it was being released from a height of 0.80 m as shown?



Exercise Set VIII: Energy Conservation and Efficiency
and Physics Practical Test Revision

Collect and complete the worksheets, then mark your work using the answers provided.

Worksheet: “Energy Conservation and Efficiency”

Worksheet: “Physics Practical Test Revision”

References

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- https://www.qld.gov.au/transport/safety/road-safety/driving-safely/stopping-distances (stopping distances infographic)
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- Pearson Science 10
- Oxford Science 10