

**Physics**



Dynamics and Space

1.2 Forces

Question Booklet

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Speed of light in materials* | | | | | |  | | | | *Speed of sound in materials* | | | | | | | |
| *Material* | | | | | *Speed in m/s* |  | | | | *Material* | | | *Speed in m/s* | | | | |
| Air | | | | | 3 x 108 |  | | | | Aluminium | | | 5 200 | | | | |
| Carbon dioxide | | | | | 3 x 108 |  | | | | Air | | | 340 | | | | |
| Diamond | | | | | 1⋅2 x 108 |  | | | | Bone | | | 4 100 | | | | |
| Glass | | | | | 2⋅0 x 108 |  | | | | Carbon dioxide | | | 270 | | | | |
| Glycerol | | | | | 2.1 x 108 |  | | | | Glycerol | | | 1 900 | | | | |
| Water | | | | | 2⋅3 x 108 |  | | | | Muscle | | | 1 600 | | | | |
|  | |  | | | |  | | | | Steel | | | 5 200 | | | | |
| *Gravitational field strengths* | | | | | | | |  | | Tissue | | | 1 500 | | | | |
|  | *Gravitational field strength on the surface in N/kg* | | | | | | |  | | Water | | | 1 500 | | | | |
|  | | | | | | | |
| Earth | 10 | | | | | | |  | | *Specific heat capacity of materials* | | | | | | | |
| Jupiter | 26 | | | | | | |  | | *Material* | | | | | *Specific heat capacity in J/kg*o*C* | | |
| Mars | 4 | | | | | | |
| Mercury | 4 | | | | | | |  | | Alcohol | | | | | 2 350 | | |
| Moon | 1⋅6 | | | | | | |  | | Aluminium | | | | | 902 | | |
| Neptune | 12 | | | | | | |  | | Copper | | | | | 386 | | |
| Saturn | 11 | | | | | | |  | | Glass | | | | | 500 | | |
| Sun | 270 | | | | | | |  | | Glycerol | | | | | 2 400 | | |
| Venus | 9 | | | | | | |  | | Ice | | | | | 2 100 | | |
| Uranus | 11⋅7 | | | | | | |  | | Lead | | | | | 128 | | |
| Pluto | 4⋅2 | | | | | | |  | | Silica | | | | | 1 033 | | |
|  |  | | | | | | |  | | Water | | | | | 4 180 | | |
|  | | | | | | | | | | Steel | | | | | 500 | | |
| *Specific latent heat of fusion of materials* | | | | | | | |  | |  | | | | | | |
| *Material* | | | | *Specific latent heat of fusion in J/kg* | | | |  | *Melting and boiling points of materials* | | | | | | | | |
| *Material* | | | *Melting point in* o*C* | | | | *Boiling point in* o*C* | |
| Alcohol | | | | 0⋅99 x 105 | | | |  |
| Aluminium | | | | 3⋅95 x 105 | | | |  | Alcohol | | | -98 | | | | 65 | |
| Carbon dioxide | | | | 1⋅80 x 105 | | | |  | Aluminium | | | 660 | | | | 2470 | |
| Copper | | | | 2⋅05 x 105 | | | |  | Copper | | | 1 077 | | | | 2 567 | |
| Glycerol | | | | 1⋅81 x 105 | | | |  | Glycerol | | | 18 | | | | 290 | |
| Lead | | | | 0⋅25 x 105 | | | |  | Lead | | | 328 | | | | 1 737 | |
| Water | | | | 3⋅34 x 105 | | | |  | Turpentine | | | -10 | | | | 156 | |
|  | | | |  | |  | | |  | | | | | | | | |
|  | | | | | |  | *SI Prefixes and Multiplication Factors* | | | | | | | | | | |
| *Specific latent heat of vaporisation of materials* | | | | | |  | *Prefix* | | | | *Symbol* | | | *Factor* | | | |
| *|Material* | | | *Sp.l.ht vap(J/kg)* | | |  | giga | | | | G | | | 1 000 000 000=109 | | | |
| Alcohol | | | 11⋅2 x 105 | | |  | mega | | | | M | | | 1 000 000 =106 | | | |
| Carbon dioxide | | | 3⋅77 x 105 | | |  | kilo | | | | k | | | 1 000 =103 | | | |
| Glycerol | | | 8⋅30 x 105 | | |  | milli | | | | m | | | 0⋅001 =10-3 | | | |
| Turpentine | | | 2⋅90 x 105 | | |  | micro | | | | μ | | | 0⋅000 001 =10-6 | | | |

**An object will stay at rest or keep moving in a straight line at a constant speed if balanced forces are acting on it.**

1. Which of the following diagrams show balanced forces?

15 N

15N

30 N

30 N

2 N

2 N

(*a*) (*b*) (*c*)

(*d*) (*e*) (*f*)

6 N

6 N

22 N

25 N

65 N

65 N

2. A fully loaded oil super-tanker moves at a constant speed of 12 m/s. It’s engines produce a constant forward force of 16 000 N. What is the size of the friction force acting on the tanker?

3. A clock hangs from a peg on a wall. If the weight of the clock is 2 N what is the size of the upward force provided by the peg?

4. David cycles along the road at a constant speed of 8 m/s. The total friction force acting on David and the bike is 550 N.

550 N



What size is the forward force provided by David pedalling?

5. A crane holds a concrete slab of mass 750 kg at a steady height while workmen prepare to position it on the building they are constructing.

(*a*) What is the weight of the concrete slab?

(*b*) What is the tension in the crane cable?

6. A helicopter is hovering at a constant height of 35 m. The upward lift force on the helicopter is 85 500 N.

85 500 N

|  |
| --- |
|  |

(*a*) What is the weight of the helicopter?

(*b*) What is the mass of the helicopter?

7. A lift travels upwards at a constant speed of 4 m/s. The mass of the lift is 800 kg and it is carrying a load which has a mass of 153 kg.

(*a*) What is the total mass of the lift and its load?

(*b*) What is the total weight of the lift and its load?

(*c*) What is the tension in the lift cable as the lift travels upwards?

(*d*) What is the tension in the lift cable when it stops at the second floor?

(*e*) The maximum tension the lift cable can provide is 16 400 N. What is the greatest mass that the cable can hold?

(*f*) If an average person has a mass of 70 kg what is the maximum number of people the lift can carry?

8. An aeroplane travels with a constant speed of 300 m/s at a height of 10 000 m. The mass of the aeroplane is 58 000 kg and the engine provides a forward force of 2 400 N.

(*a*) What size is the frictional force acting on the aeroplane?

(*b*) What size is the lift force acting on the plane at this height

9. In a tug of war the blue team pull the red team with a force of 3000 N to the left. The two teams remain stationary.

|  |
| --- |
| 3 000 N |

1. What is the size and direction of the force exerted by the red team on the blue team?
2. Each member of the red team can pull with an average force of

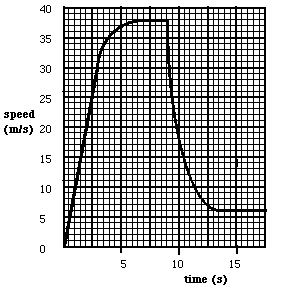
250 N. Calculate how many people there are in the red team.

1. One of the members of the red team sprains her ankle and has to leave the competition. What would be the force exerted by the

red team now?

1. What would happen now?

10. David is doing a parachute jump to raise money for charity. The graph below shows his speed at different points in his journey. Use this graph to answer the questions below.



(*a*) During what time was David travelling at a constant speed?

(*b*) At what time did David open his parachute?

(*c*) Describe the forces acting on David 15 seconds after he jumped out

of the plane.

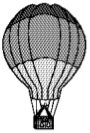
(*d*) 16 seconds after jumping out of the plane the friction force acting on David was 745 N. Calculate David’s mass .

(*e*) What would be the size of the friction force acting on David 8 seconds after leaving the plane?

1. The diagram shows the forces acting on a balloon as it rises.

Buoyancy force

= 2000N



a) What will be the size of force A?

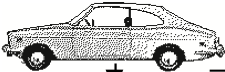
Balloon rising at a constant velocity

b) If the balloon was falling at a constant

velocity, what would be the size of force A?

Force A

1. The diagram below shows the forces acting on a car moving at constant velocity.



Air resistance 400N

Road Friction 450N

Force E

Road Reaction 10,000N

Force D

a) What can you say about the unbalanced force acting on this car?

b) How big is the engine force E?

c) What is the weight of the car D?

1. Explain, using Newton’s First Law, why passengers without seat belts in a stationary car are thrown forwards in the car, when the car stops suddenly.
2. Explain how a parachutist reaches a terminal velocity.
3. Describe two methods of

a) increasing friction b) decreasing friction.

1. Where, in a bicycle, is friction deliberately

a) increased b) decreased?

In this section you can use the equation:

**Unbalanced force = mass x acceleration**

also written as

**F = ma**

where **F** = Unbalanced force in newtons (N)

**m** = mass in kilograms (kg)

**a** = acceleration in metres per second per second (m/s 2)

1. Find the missing values in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Force (N) | Mass (kg) | Acceleration (m/s2) |
| (a) |  | 2 | 4 |
| (b) |  | 6 | 3 |
| (c) | 20 | 0.2 |  |
| (d) | 900 |  | 10 |
| (e) | 28.8 |  | 3.5 |
| (f) | 450 | 20 |  |

2. Calculate the force required to accelerate a mass of 12 kg at 2 m/s2.

3. Calculate the force required to accelerate a car of mass 1000 kg at 5 m/s2.

4. If a force of 500 N is applied to a mass of 20 kg, calculate its acceleration.

5. A man pushes a stacked trolley of mass 25 kg with a force of 25 N. Calculate the acceleration of the trolley.

6. Find the mass of a boy and his bike if they accelerate at 1·5 m/s2 when pushed with a force of 65 N.

7. A car on an automatic wash and valet machine is pulled by a force of 500 N and accelerates at 0·25 m/s2. What is the mass of the car?

8. A forklift truck applies a force of 2 kN to move a crate of mass 1700 kg. Calculate the acceleration of the crate.

9. A bus applies a braking force of 2·4 kN in order to avoid a road accident ahead. The mass of the bus and the people on board is 4000 kg. Calculate the deceleration of the bus.

10. A table tennis ball of mass 30 g is found to accelerate at 150 m/s2 when hit with a bat. Calculate the force causing the ball to accelerate.

11. Calculate the acceleration of a steel ball bearing of mass 100 g when fired with a force of 1·5 N in a pin ball machine.

12. A ship of mass 1 x 107 kg is accelerated by a force of 3·2 x106 N. Calculate the size of the acceleration.

13. An oil tanker of mass 1·5 x108 kg accelerates at 2 m/s2. Calculate the unbalanced force required to cause this acceleration.

14. A 70 kg sledge is pulled along as shown below

250N

50N



If the resistive force has a value of 50 N, calculate :

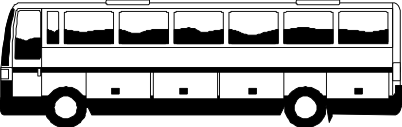
(*a*) the unbalanced force acting

(*b*) the acceleration of the sledge.

15. The forces acting on a bus are shown below

3600N

1600N



If the mass of the bus and passengers on board is 4 500 kg calculate:

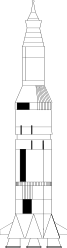
(*a*) the unbalanced force acting

(*b*) the acceleration of the bus.

16. The forces acting on a rocket at launch are as shown below.

Thrust = 7 500 kN

Weight = 3 000 kN



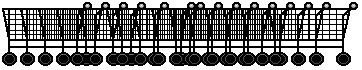
Use the information to calculate:

1. the mass of the rocket
2. the unbalanced force acting on the rocket
3. the acceleration of the rocket at lift off.

|  |
| --- |
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17. A car of mass 1 200 kg is accelerating along a dual carriageway at a constant rate of 3 m/s2. If the engine force is 3 800 N calculate the force of friction between the tyres and the road surface.

18. A supermarket assistant is collecting trolleys from the car park to return to the store. He applies a force of 40 N to a set of 15 trolleys as shown below:



40 N

mass of each trolley = 25 kg

(*a*) Calculate the acceleration of the trolleys.

(*b*) If the belt breaks and 5 trolleys become separated calculate the new

acceleration of the remaining trolleys. Assume that the assistant continues to apply a force of 40 N.

19. Forces acting on a train of mass 50 000 kg are as shown below.



7 000 N

900 N

Calculate:

(*a*) the unbalanced force acting on the train

(*b*) the acceleration of the train.

20. A car accelerates at 0·6 m/s2 when it’s engine force is 1 000 N and frictional forces against it are 450 N. Find the mass of the car.

21. A car of mass 1 200 kg is accelerated from rest to 8 m/s in 8 s. Calculate:

(*a*) the acceleration of the car

(*b*) the engine force required to produce this acceleration assuming no friction.

22. A 7500 kg rocket is designed to travel to Mars. In order to escape the pull of the Earth’s gravity the rocket has to reach a speed of 11 000 m/s. If the rocket takes 5 minutes to reach this speed, calculate:

(*a*) the acceleration of the rocket

(*b*) the unbalanced force acting on the rocket

(*c*) the engine thrust required to produce this acceleration.

23. A motorcycle is accelerated from rest to 60 m/s in 16 seconds. If the engine force required to achieve this is 1200 N, and effects due to friction are ignored, calculate the mass of the motor cycle.

24. A train is travelling through a woodland area when the driver notices a tree on the track. He immediately applies the brakes and manages to slow the train down from 25 m/s to rest in 6 seconds. If the train has a mass of 60,000 kg calculate the size of the braking force.

25. A bike is pushed from rest to a speed of 3 m/s in 2·5 seconds. If the mass of the bike and rider are 100 kg calculate the size of the pushing force required.

1. What force is needed to accelerate a 5 kg mass at 3 m/s2 ?
2. What will be the acceleration of a 12 kg mass acted on by a force of 30 N?
3. What mass would accelerate at 2 m/s2 when acted on by a 12 N force?
4. What force will accelerate 250 g at 2 m/s2?
5. What force would be needed to accelerate a 10 tonne lorry at 1.5 m/s2?

(1 tonne = 1000 kg)

1. Give two reasons why a car will have a smaller acceleration in similar conditions when a roof rack is added.
2. Describe an experiment to investigate the effect of varying the unbalanced force acting on a fixed mass.
3. A car of mass 1200 kg experiences friction equal to 500 N when travelling at a certain speed. If the engine force is 1400 N, what will be the car’s acceleration?
4. A car of mass 2000 kg has a total engine force of 4500 N. The frictional drag force acting against the car is 1700 N. What is the acceleration of the car?
5. Two girls push a car of mass 1000 kg. Each pushes with a force of 100 N and the force of friction is 120 N. Calculate the acceleration of the car.
6. A boat engine produces a force of 10000 N and the friction and water resistance total 3500 N. If the mass of the boat is 2000 kg, what will be its acceleration?
7. A careless driver tries to start his car with the hand brake still on. The engine exerts a force of 2500 N and the hand brake exerts a force of 1300 N. The car moves off with an acceleration of 1.2 m/s2. What is the mass of the car?
8. A car of mass 1200 kg can accelerate at 2 m/s2 with an engine force of 3000 N. What must be the total friction force acting on the car?
9. A helicopter winches an injured climber up from a mountainside. The climber’s mass is 65 kg.

a) What is the weight of the climber?

b) If he is accelerated upwards at 1.0 m/s2, what unbalanced force is required?

c) What total upwards force must be produced by the helicopter?

1. An 800 kg car is accelerated from 0 to 18 m/s in 12 seconds. a) What is the resultant force acting on the car?

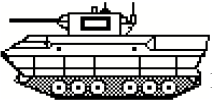
b) At the end of the 12 s period the brakes are operated and the car comes to rest in a time of 5 s. What is the average braking force acting on the car?

1. What is meant by the resultant force on an object?
2. What are the resultants of the following forces?

a)

1200N

2000N



b)

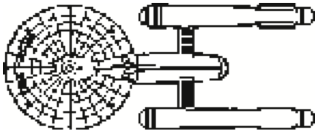
600N

700N



50,000N

50,000N



c)

1. By using a scale diagram or otherwise, find the resultant of the following pairs of forces.

5N

15N

b)

5N

12N

a)

N

10N

8N

d)

18N

24N

c)

In this section you can use the equation:

**weight = mass x gravitational field strength**

also written as

**W = mg**

where **W** = weight in newtons (N)

**m** = mass in kilograms (kg)

**g** = gravitational field strength in newtons per kilogram (N/kg).

1. Find the missing values in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Weight (N) | Mass (kg) | Gravitational Field Strength (N/kg) |
| (a) |  | 300 | 10.0 |
| (b) |  | 0.6 | 3.7 |
| (c) |  | 0.2 | 11.7 |
| (d) | 230 |  | 10.0 |
| (e) | 1680 |  | 11.7 |
| (f) | 69 | 6.0 |  |

2. Calculate the weight of each of the following on Earth :

(*a*) a girl whose mass is 50 kg

(*b*) a dog of mass 20 kg

(*c*) a 9 kg box

(*d*) a ball of mass 0·5 kg

(*e*) an insect whose mass is 5 x 10-5 kg

(*f*) a particle of mass 2 x 10-27 kg.

3. Calculate the mass of each of the following weighed on Earth:

(*a*) a man who weighs 750 N

(*b*) a tin of peas which weighs 4·5 N

(*c*) a chair which weighs 350 N

(*d*) a rabbit which weighs 40 N

(*e*) a car which weighs 1·4 x 104 N

(*f*) a thread which weighs 3 x 10-4 N.

4. The mass of a puncture repair kit is 30 g. What is its weight on Earth?

5. Calculate the weight on Earth of a postcard which has a mass of 2 g.

*Helpful Hint*

Gravitational field strengths vary on each planet. You will need to refer to the data sheet on page 2 for actual values.

6. What does a 500 g packet of cornflakes weigh:

(*a*) on Earth (*b*) on the Moon (*c*) in Space?

7. An astronaut has a weight of 800 N on Earth . What is his mass:

(a) on Earth (b) on the Moon (c) in Space?

8. A question in a Physics examination asked, ‘What is meant by the weight of an object?’ Two pupils, Steven and Nicola, answered as follows :

Steven - ‘The weight of an object is the gravitational field strength.’

Nicola - ‘ The weight of an object is the force of gravity acting on the object.’

(*a*) Who was correct?

(*b*) What does the term ‘gravitational field strength’ mean?

9. A lift has a weight of 9 000 N on Earth.

(*a*) What is the force of gravity acting on the lift?

(*b*) What is the mass of the lift?

10. A rocket of mass 2 x 106 kg travels from Saturn to Earth.

(*a*) What is the weight of the rocket on Saturn?

(*b*) What is the weight of the rocket on Earth?

11. A paper aeroplane has a mass of 10 g.

(*a*) What is the force of gravity acting on the paper aeroplane on Earth?

(*b*) What is the gravitational field strength on Earth?

12. A Vauxhall Nova weighs 13 kN on Earth.

(*a*) What is the mass of the Vauxhall Nova?

(*b*) What is the force of gravity acting on the vehicle on Earth?

13. A small tin of oil has a mass of 300 g.

(*a*) What does the tin of oil weigh on Earth?

(*b*) What would be the mass of the tin of oil on Jupiter?

14. If a man has a weight of 700 N on Earth, what will he weigh on Neptune?

15. A snail has a weight of 0⋅5 N on Earth. What would be its mass on the Moon?

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**Acceleration due to gravity and gravitational field strength**

On the moon, where the gravitational field strength is 1.6N/kg, a stone falls and takes 1.5s to reach the surface. What is its velocity as it hits the surface of the moon?

## Weight

In this section you can use the equation:

**weight = mass x gravitational field strength**

also written as

**W = mg**

where **W** = weight in Newtons (N)

**m** = mass in kilograms (kg)

**g** = gravitational field strength in Newtons per kilogram (N/kg)

*Helpful Hint*

On Earth ‘**g’ = 10 N/kg** but it varies from planet to planet. In questions about weight on other planets you must use these values by referring to the **data sheet** on page 2.

1. Find the missing values in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mass (kg) | Gravitational Field Strength (N/kg) | Weight (N) |
| (a) | 12 | 10 |  |
| (b) | 279 | 4 |  |
| (c) | 0.56 |  | 5.6 |
| (d) | 7.89 |  | 78.9 |
| (e) |  | 12 | 700 |
| (f) |  | 10 | 58 |

2. Calculate the weight of a 70 kg man on Earth.

3. If a moon rock has a weight of 4·6 N, what is its mass

1. An objects weight depends on the strength of the gravitational field around it. A scientist records the weight of a 3 kg rock on each planet and records the information in the table below.

Planet Weight(N)

Earth 30

Jupiter 78

Mars 12

Mercury 12

Neptune 36

Saturn 33

Venus 27

Uranus 35·1

Pluto 12·6

Use the results from the table to work out the value of the gravitational field strength on each planet ( you can check your answers against the data sheet on page 2).

5. Using your results to question 4, state which planet(s) have:

(*a*) the strongest gravitational field strength

(*b*) the weakest gravitational field strength

(*c*) a gravitational field strength nearest to that on Earth

(*d*) a gravitational field strength three times as strong as that on Mercury.

6. Which is heavier, a 2 kg stone on Neptune or a 0·9 kg rock on Jupiter?

7. How much lighter does a 65 kg woman seem on the moon, where ‘g’ = 1·6 N/kg, than on Earth?

8. Find the weight of a satellite booster on Mars if it weighs 24 N on the moon.

9. What is the difference in **mass** between a 40 N weight on Venus and a 104 N weight on Jupiter?

10. A rock weighs approximately two and a half times its weight on Earth somewhere in our solar system. Where is it likely to be?

1. A rocket of mass 1.95 x 106 kg travels from Saturn to Earth.

(*a*) What is the weight of the rocket on Saturn?

(*b*) What is the weight of the rocket on Earth?

(c) What is the weight of the rocket when it is in transit through space?

The data table on page 2 may be required for questions 1 – 8.

Assume the questions refer to the Earth unless otherwise stated.

1. What is the weight of a 10 kg bag of potatoes?
2. What is the weight of a 250 g bag of sweets?
3. What is the mass of a 450 N girl?
4. What is the weight of a 10,000 kg spacecraft on
   1. Earth b) Mars c) Venus?
5. What would a 60 kg man weigh on Jupiter?
6. Which planet’s gravity is closest to our own?
7. An astronaut who weighs 700 N on Earth goes to a planet where he weighs 280 N. Calculate his mass and state which planet he was on.
8. What would an astronaut weigh on Earth, if his weight on Venus was 540 N?

1. A forklift truck is being used in a warehouse to load packing cases full of electric kettles onto a waiting lorry. Each packing case has a mass of 48 kg.

(*a*) Calculate the weight of one packing case.

(*b*) The forklift truck is able to lift two cases at a time. Calculate the minimum force required to lift two cases.

(*c*) The forklift truck travels at a constant speed of 7 m/s across the warehouse to the waiting lorry. If the total frictional force acting on the truck is 500 N calculate the forward force provided by the forklift truck’s engine.

2. During the summer two friends set off on a trip in a balloon. When the balloon is released from its mooring it rises with a constant acceleration of 0·8 m/s2. The mass of the balloon and all its cargo is 360 kg.



(*a*) Draw a diagram showing the forces acting on the balloon at the instant it is released from its mooring.

(*b*) Calculate the weight of the balloon and all its cargo.

(*c*) Calculate the unbalanced force which is causing the balloon to accelerate upwards.

(*d*) Calculate the size of the upwards force on the balloon .

The passengers decide to throw two sandbags overboard to help them increase their height more quickly. Each sandbag has a mass of 5 kg.

(*e*) Calculate the new weight of the balloon and its cargo.

(*f*) Assuming that the upward force stays the same as that calculated in part (*d)* calculate the new acceleration of the balloon.

# 

In this section you can use the equation:

**work done = force x distance**

also written as

**Ew = Fd**

where **Ew** = work done in joules (J)

**F** = force in newtons (N)

**d** = distance in metres (m).

1. Find the missing values in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Force (N) | Distance (m) | Work Done (J) |
| (a) | 150 | 25 |  |
| (b) | 6.5 x 103 | 320 |  |
| (c) |  | 52 | 6500 |
| (d) |  | 72.7 x 10-3 | 2 |
| (e) | 2 |  | 542 |
| (f) | 90 |  | 1.45 x 106 |

2. A gardener pushes a wheelbarrow with a force of 250 N over a distance of 20 m. Calculate how much work he does.

3. Fiona pushes a pram with a force of 150 N. If she does 30 000 J of work calculate how far she pushes the pram.

4. Joseph pulls his sledge to the top of a hill. He does 1 500 joules of work and pulls the sledge a distance of 50 metres. With what force does he pull the sledge?

5. A horse pulls a cart 3 km along a road. The horse does 400 kJ of work. What force does the horse exert on the cart?

6. A car tows a caravan with a constant force of 2·5 kN over part of its journey. If the car does 8·5 x 106 J of work calculate how far it pulls the caravan.

7. During a race a motorcycle engine produced a steady forward force of 130 N.

Calculate the work done by the engine if the motorcycle covered a distance of 50 km.

8. A motor boat tows a yacht out of a harbour. If the motor boat exerted a force of 110 kN and did 200 MJ of work calculate how far it towed the yacht.

9. A locomotive exerts a force of 15 kN on a train of carriages. The locomotive pulls the train over a distance of 5 x 103 m. Calculate the work done by the locomotive.

10. Peter and John work at a supermarket. They are responsible for collecting trolleys from the trolley parks in the car park and returning them to the store.

(*a*) Peter collects trolleys from the furthest trolley park. He has to pull them 150 m back to the store and collects 10 trolleys at a time. If Peter pulls the 10 trolleys together with an average force of 350 N calculate how much work he does in one journey.

(*b*) John does not have so far to walk so he collects 20 trolleys at a time. He pulls his trolleys with an average force of 525 N and covers 100 m each journey. Calculate how much work he does in one trip.

(*c*) Each boy has to return 80 trolleys to the store before finishing their shift.

(*i*) Calculate how many journeys each boy has to make.

(*ii*) Show by calculation who does the most work.

11. On an expedition to the North Pole, Husky dogs were used to pull the sledges carrying supplies for the journey. One team of dogs did 650 MJ of work during the 1 500 km journey.

(*a*) Calculate the average force that the team of dogs exerted on the sledge.

(*b*) There are 8 dogs in a team. Calculate the average force exerted by each dog during the journey.

12. How far can a milk float travel if the electric engine can produce a steady force of 2 kN and can do 9 500 kJ of work before the battery needs recharged?

*Helpful Hint*

**Special case**

When work is done **lifting** an object the force required is equal to

the **weight** of the object .

13. A painter is painting the ceiling of a room. She fills her tray with paint and lifts it up the ladder. The weight of the full paint tray is 30 newtons and she lifts it a distance of 2 metres up the ladder. Calculate the amount of work she does.

14. Marco climbs a rope in the school gym during his P.E. lesson. He weighs 600 N and climbs 8 m up the rope. Calculate how much work he does.

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15. A chair lift carries two skiers and their equipment to the top of a ski run which is at a height of 300 m. The chair lift weighs 500 N and the skiers with their equipment weigh 1 800 N. Calculate the work done by the chair lift motor in lifting the skiers to the top of the ski run.

16. A crane lifts a concrete block through a height of 40 m. The crane does 650 kJ of work.

Calculate

* + - * 1. the weight of the concrete block
        2. the mass of the concrete block

17. A librarian is placing books on to the fiction shelf which is 2 metres from the ground. He does 80 joules of work lifting the books from the floor to the shelf.

(*a*) Calculate the weight of the books.

(*b*) What is the mass of the books?

(*c*) If each book has an average mass of 400 g calculate how many books the librarian places on the shelf.

18. A search and rescue helicopter is called to a ship in the North Sea to airlift an injured sailor to hospital. The helicopter lifts the sailor 150 m at a constant speed of 4 m/s . The sailor has a mass of 75 kg. Calculate:

|  |
| --- |
|  |

(*a*) the weight of the sailor

(*b*) the work done by the helicopter during this lifting operation.

19. Brian is learning to rock climb. After two weeks of practice he can climb 10 m up the practice wall without help. Brian has a mass of 82 kg.

(*a*) Calculate Brian’s weight.

(*b*) Calculate the amount of work Brian does climbing the wall.

20. In a supermarket shop assistants are asked to stack the shelves with tins of beans. Each tin of beans has a mass of 450 g. Jane lifts 150 cans of beans from the box on the floor to the middle shelf. The shelf is 140 cm from the floor.

(*a*) Calculate the weight of 150 cans of beans.

(*b*) Calculate how much work Jane does.

(*c*) Martin has been asked to stack the top shelf. The top shelf is 200 cm from the floor. He lifts 150 cans of beans from the box on the floor onto the shelf.

Calculate how much **more** work he does than Jane.

# Work and Energy

1. A locomotive exerts a pull of 10000 N to pull a train a distance of 400 m. How much work is done?
2. A gardener does 1200 J pushing a wheelbarrow with a force of 100 N. How far did she push the barrow?
3. A man uses up 1000 J by pulling a heavy load for 20 m. What force did he use?
4. A girl is pushing her bike with a force of 80 N and uses up 4000 J of energy. How far did she push the bike?
5. A man weighing 600 N climbs stairs in an office block, which are 40 m high. How much work does he do?

6. A worker pushes a 4 kg crate along the ground for 3m using a force of

20N, then lifts the crate up to a ledge 1 m high. How much work does he do altogether?

## 

1. Use Newton’s Third Law of Motion to identify pairs of action and reaction forces in the following situations:-

(a) Kicking a ball. (b) Pushing yourself along on a skateboard (c) Rowing a boat

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2. The Chinese first used rockets in the thirteenth century as weapons of war. These rockets used a type of gunpowder as the propellant. Modern rockets tend to be liquid fuelled but work on the same principle as the early rockets.

(*a*) Use Newton’s third law to explain how a rocket engine propels a rocket forward.

(b) The acceleration of the rocket increases as it burns up fuel even though the thrust provided by the engine remains constant. Explain

why.

(c) Once in space the rocket engines are switched off. Describe the motion of the rocket now and explain its motion in terms of Newton’s laws.

1. State Newton’s Third Law.
2. Identify the ‘Newton pairs’ in the following situations.

a)

Golf club strikes ball



Snooker cue strikes ball

b)



Space shuttle on take-off (consider only the forces between the shuttle and the exhaust gases)

c)

**Newton’s First Law P3**

1. (b), (c), (d) and (f)

2. 16 000 N

3. 2 N

4. 550 N

5. (a) 7 500 N

(b) 7 500 N 6. (a) 85 500 N (b) 8 550 kg7. (a) 953 kg

(b) 9 530 N

(c) 9 530 N

(d) 9 530 N

(e) 1 640 kg

(f) 12 people

8. (a) 3 000 N to the right

(b) 12(c) 2 750 N

9. (a) 6 - 9 minutes

(b) 9 minutes

(d) 745 kg

(e) 745 N

10. (a) 2 400 N

(b) 580 000 N

**Balanced Forces and Newton’s First Law P7**

1. (a) 2000N
   1. 2000N
2. (a) The car is moving at constant speed so there is no unbalanced force.

(b) 850N

(c) 10,000N

3. When the car stops the passenger continues to move forwards at the original speed. They continue to do so until they are stopped by another force (such as hitting the windscreen).

4. When a parachutist falls they accelerate due to gravity until the air resistance equals their weight. At that point the forces are balanced and they move at constant speed.

**Friction P8**

1. (a) Friction can be increased by making the surface rough, by increasing the surface area, by increasing the force applied or other suitable answer

(b) Friction can be decreased by making the surface smoother, decreasing the surface area in contact, using lubrication (oil, grease, wax etc) or other suitable answer

2 (a) Friction is increased at the brakes (brake block on rim), at the tyres and at the pedals (so that your feet do not slip off)

(b) Friction is decreased at the chain (so that the gear does not stick), at the hub of the wheel so that it turns freely and at the head tube so that the steering moves freely.

**Newton’s Second Law 1 P9**

1. (a) 8 N

(b) 18 N

(c) 100 m/s2

(d) 90 kg

(e) 823 kg

(f) 225 m/s2

2. 24 N

3. 5 000 N

4. 25 m/s2

5. 1 m/s2

6. 4333 kg

7. 2 000 kg

8. 118 m/s2

9. 06 m/s2

10. 45 N

11. 15 m/s2

12. 032 m/s2

13. 3 x 108 N

14. (a) 200 N

(b) 286 m/s2

15. (a) 2 000 N

(b) 044 m/s2

16. (a) 300 000 kg

(b) 4 500 kN

(c) 15 m/s2

17. 200 N

18. (a) 011 m/s2

(b) 013 m/s2

19. (a) 6 100 N

(b) 012 m/s2

20. 917 kg

21. (a) 1 m/s2

(b) 1 200 N

22. (a) 3667 m/s2

(b) 275 000 N

(c) 350 000 N

23. 320 kg

24. 250 200 N

25. 120 N

**Newton’s Second Law 2 P 13**

1. 15N
2. 2.5 m/s2
3. 60 kg
4. 0.5N
5. 15,000N

5. Adding a roof-rack increases the surface area of the car and decreases the streamlining. These both increase the air resistance experienced by the car and mean that the unbalanced force will be lower. This in turn decreases the acceleration.

1. Use a trolley sitting on a track which has a pulley at the end. Masses are suspended from a hanger tied to a thread which passes over the pulley, causing a downwards force. To keep the mass of the system constant any masses not on the hanger must be placed on the trolley. A mask is placed on top of the trolley which passes through a light gate when the trolley accelerates down the slope. The acceleration caused by each unbalanced force is recorded an plotted on a graph of acceleration against change in force. As the force increases the acceleration increases.
2. 0.75 m/s2
3. 1.4 m/s2
4. 0.08m/s2
5. 3.25 m/s2
6. 1000 kg
7. 600N
8. (a) 650N

(b) 65N

1. (a) 1200N

(b) 2880N

**Resultant Forces P15**

1. The resultant force is the single force which can replace all the other forces acting on the object.
2. (a) 800N to left

(b)100N down

(c)100,000N to right

3. (a) 13N at (067)

(b) 15,8N at (198)

(c) 30N at (053)

(d) 12.8N at (309)

**Weight 1 P 16**

1. (a) 3000 N

(b) 2.22 N

(c) 2.34 N

(d) 23 kg

(e) 143.59 kg

(f) 11.5 N/kg

2. (a) 500 N

(b) 200 N

(c) 90 N

(d) 5 N

(e) 5 x 10-4 N

(f) 2 x 10-26 N

3. (a) 75 kg

(b) 0.45 kg

(c) 35 kg

(d) 4 kg

(e) 1.4 x 103 kg

(f) 3 x 10-5 kg4. 0.3 N

5. 0.02 N

6. (a) 5 N

(b) 0.8 N

(c) 0 N

7. (a) 80 kg

(b) 80 kg

(c) 80 kg

8. (a) Nicola is correct.

(b) The gravitational field strength is the weight per unit mass acting on an object.

9. (a) 9000 N

(b) 900 kg

10. (a) 2.2 x 107 N

(b) 2 x 107 N

11. (a) 0.1 N

(b) 10 N/kg

12. (a) 1300 kg

(b) 13 kN

13. (a) 3 N

(b) 300 g

14. 840 N

15. 0.05 kg

**Acceleration due to Gravity and Gravitational Field Strength P18**

2,4 m/s

**Weight 2 P 19**

|  |
| --- |
| 1. (a) 120 N |
| (b) 1 116 N |
| (c) 10 N/kg |
| (d) 10 N/kg |
| (e) 58.33kg |
| (f) 5.8 kg |
| 2. 700 N |
| 1. 2.88 kg   4. Earth 10 N/kg  Jupiter 26 N/kg  Mars 4 N/kg  Mercury 4 N/kg  Neptune 9 N/kg  Saturn 11 N/kg  Venus 9 N/kg  Uranus 11.7 N/kg  Pluto 4.2 N/kg |
| 5. (a) Jupiter |
| (b) Mars and Mercury |
| (c) Saturn & Venus |
| (d)Neptune  6. 2kg stone on Neptune  7. 546N  8. 60N  9. 0.44kg  10. Jupiter |
|  |

**Gravity Mass and Weight 1 P 21**

1. (a) 2.145 x 107 N

(b) 1.95 x 107 N

(c) 0 N

**Gravity Mass and Weight 2 P 22**

1. 100N
2. 2.5N
3. 45kg
4. (a) 100,000N

(b) 40,000N

(c) 90,000N

5. 1560N

6. Venus, Saturn (when measured to 1 d.p.)

7. 70kg Mars

8. 60kg

**Miscellaneous Questions P 23**

1. (a) 480 N



Weight

Air Resistance

(b) 960 N

(c) 500 N2. (b) 3600 N

Lift (from hot air)

(c) 288 N

(d) 3888 N

(e) 3500 N

(f) 1.11 m/s2

**Movement means Energy - Work P 24**

1. (a) 3,750 J

(b) 2,080,000 J

(c) 125 N

(d) 27.51 N

(e) 271 m

(f) 16,111 m

2. 5000 J

3. 200 m

4. 30 N

5. 133.33 N

6. 3,400 m

7. 6,500,000 J

8. 1,818 m

9. 7.5 x 107 J

10. (a) 433.33 N

(b) 54.17 N

11. 4,750 m

12. (a) 52,500 J

(b) 52,500 J

1. (i) Peter - 8,

John - 4

(ii) Peter

13. 60 J

14. 4,800 J

15. 690,000 J

16. (a) 16,250 N

(b) 1,625 kg

17. (a) 40 N

(b) 4 kg

(c) 10 books

18. (a) 750 N

(b) 112,500 J

19. (a) 820 N

(b) 8,200 J

20. (a) 675 N

(b) 945 J

(c) 405 J

**Work and Energy P28**

1. 4MJ
2. 12m
3. 50N
4. 50m
5. 24kJ
6. 100J

**Newton’s Third Law 1 P 29**

1. (a) Your foot pushes on the ball and the ball pushes back on your foot.

(b) Your foot pushes on the ground and the ground pushes back on your foot.

(c) The oars push on the water and the water pushes back on the oars.

2. (a) A high speed stream of hot gases (produced by burning fuel) is pushed backwards from the rocket with a large force and a force of the same size pushes the rocket forwards.

Action: Rocket pushes hot gases backwards

Reaction: Hot gases push rocket forwards.

(b) As the rocket rises

* fuel is burned causing the weight to decrease
* the gravitational field strength decreases with height\
* the air resistance decreases with height

Each of these increases the unbalanced force, so the acceleration will also increase.

(c) When the rocket engine is switched off it continues to move at constant speed in a straight line. This is Newton’s First Law. It will continue to do so until acted on by an external force.

**Newton’s Third Law 2 P 30**

1. Newton’s Third Law states that:

If an object A exerts a force (the action) on object B, then object B will exert an equal, but opposite force (the reaction) on object A.

2. (a) golf club pushes on the ball and the ball pushes back on the golf club. (b) snooker cue pushes on the ball and the ball pushes back on the cue

(c) gases push up on the shuttle and the shuttle pushes back down on the gases.