



UNDERSTAND



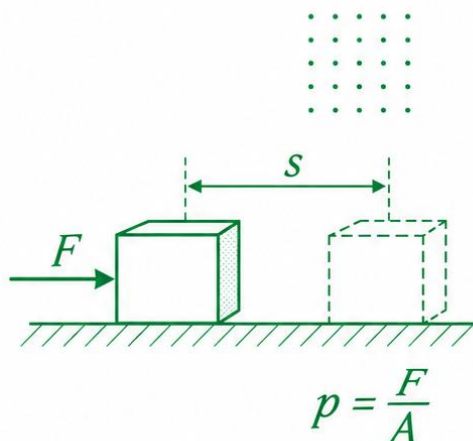
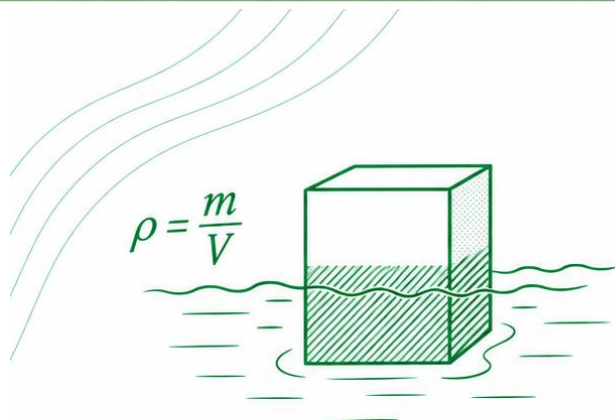
APPLY



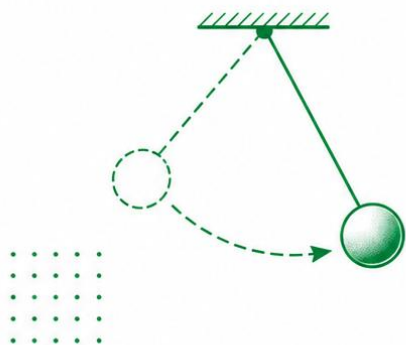
PRACTISE



IMPROVE



Density, Pressure, Work, Energy and Power



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

$$P = \frac{W}{t}$$

OWNER DETAILS

NAME:

GROUP:

TEACHER:



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5-A-Day

Write a definition or statement for each item.

1. Acceleration.
2. Newton's second law.
3. The newton (the SI unit of force).
4. The principle of moments.
5. The torque of a couple.

5-A-Day

Use $g = 9.81 \text{ N kg}^{-1}$.

1. Define pressure and density.
2. A uniform cube has side length 0.20 m and mass 10 kg. Calculate its density.
3. The cube rests on one full face on a desk. Calculate the pressure it exerts.
4. The cube is balanced on the circular top of a vertical pole of radius 4.0 cm. Calculate the contact pressure.
5. The cube is cut into two equal pieces. Explain what happens to the density of each piece.

5-A-Day

Use $g = 9.81 \text{ N kg}^{-1}$. For the atmosphere model, take constant air density and sea-level pressure $1.00 \times 10^5 \text{ Pa}$.

1. A 5.0 m^3 sample of air has mass 6.5 kg . Calculate its density.
2. Use this uniform-density model to show that the atmosphere would be approximately 8 km deep.
3. A mountain peak is 1500 m above sea level. Calculate its atmospheric pressure using the same model.
4. Seawater has density 1030 kg m^{-3} . Calculate the absolute pressure on a balloon 100 m below its surface.
5. Name the force on the submerged balloon that acts upwards.

5-A-Day

Use $g=9.81 \text{ N kg}^{-1}$. Treat the balloon's volume as constant at 15 m^3 and ignore air resistance.

1. Define upthrust.
2. Air has density 1.3 kg m^{-3} . Calculate the mass of 15 m^3 of air.
3. Calculate the upthrust on the 15 m^3 balloon at ground level.
4. The balloon is released and initially accelerates upwards at 3.2 m s^{-2} . Find its total mass, including the enclosed gas and monitoring equipment.
5. At a higher altitude, the air density is 0.90 kg m^{-3} . Calculate the ratio of ground-level upthrust to upthrust at this altitude.

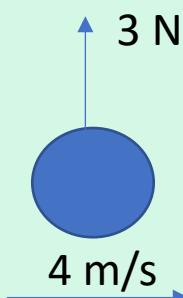
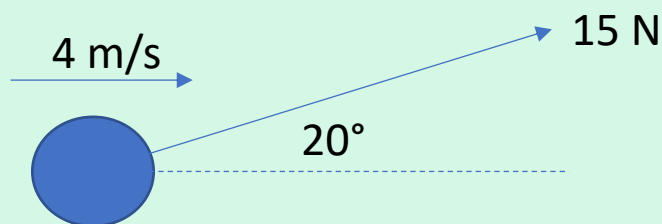
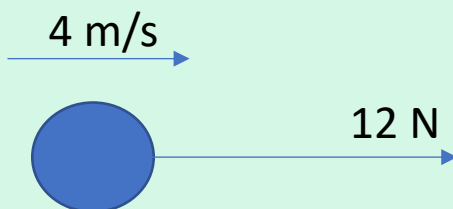
5-A-Day

Use $g=9.81 \text{ N kg}^{-1}$. The sphere stays fully submerged; use an ideal model with no water resistance.

1. A sphere has volume 2.5 cm^3 . Convert this to m^3 .
2. It is immersed in water of density 1000 kg m^{-3} . Calculate its upthrust.
3. Its material has density 7800 kg m^{-3} . Calculate its weight.
4. The sphere is released from rest. Calculate its acceleration and give its direction.
5. Assuming this acceleration remains constant, calculate how far it travels in 3.2 s.

5-A-Day

1. Define the term work done.
2. A 1.2 N force opposes motion for 4.0 m. Calculate the work done by this force. State its sign.
3. Calculate the work done by each labelled force as its object moves 2.0 m to the right.



5-A-Day

Use $g=9.81 \text{ N kg}^{-1}$. Treat the ball as a particle and ignore air resistance.

1. A 0.200 kg ball is held 0.80 m above a tray of sand. Calculate its GPE relative to the sand surface.
2. It is released from rest. State its KE just before it hits the sand.
3. Calculate its speed just before it hits the sand.
4. It stops after penetrating 1.5 cm. Calculate the average upward force exerted by the sand. Include work done by gravity during penetration.
5. The impact speed is doubled. Explain how the penetration distance changes if the sand exerts the same constant resistive force.

5-A-Day

Use $g=9.81 \text{ N kg}^{-1}$. A generator supplies an ideal lifting motor; ignore losses in the motor.

1. Define power.
2. A heater transfers 2.0 kJ of electrical energy to thermal energy each minute. Calculate its power.
3. A petrol generator receives chemical energy at 500 W and is 40% efficient. Calculate its useful energy output each second.
4. The motor lifts 1500 kg through 5.0 m at steady speed. Calculate the useful energy needed.
5. Calculate the minimum time for the generator and motor to lift the mass through 5.0 m.

5-A-Day

Use $g=9.81 \text{ N kg}^{-1}$. A 0.300 kg particle starts from rest on a straight slope. The frictional force is constant at 0.22 N ; ignore other resistance.

1. Define velocity, acceleration, power, work done, moment, the principle of moments, Newton's second law and the newton.
2. After 3.0 s the speed is 7.8 m s^{-1} . Sketch the forces and calculate the angle of the slope to the horizontal.
3. The particle reaches the bottom 6.0 s after release. Calculate its KE there.
4. Calculate the work done against friction during the descent.
5. Use energy conservation to calculate the vertical height of the slope.

Using this workbook

Show your substitutions, unit conversions and final answers with units. Use the blank areas and the extra working pages for calculations and diagrams.

Constants and units

Quantity	Value
Gravitational field strength, g	9.81 N kg ⁻¹
Water density (unless otherwise given)	1000 kg m ⁻³
Atmospheric pressure (when needed)	1.00×10 ⁵ Pa
Sphere volume; cylinder volume	$\frac{4\pi r^3}{3}$; $\pi r^2 l$

Modelling assumptions

- Use the data in each question if they differ from these defaults.
- Treat objects as particles and ignore rotational kinetic energy. Ignore air resistance and other losses unless they are given or are the subject of the question.
- For braking calculations, assume constant deceleration unless a different model is stated. For lifting at steady speed, the kinetic energy does not change.
- For $p=\rho gh$, calculate pressure due to the fluid column (gauge pressure). For absolute pressure, add the pressure at the surface. Pressure uses the force normal to the area.
- A force can do negative work. Quote positive values for the magnitude of resistive forces and for energy dissipated.
- Use $W=Fs$ and $P=Fv$ only when force is parallel to the motion. Otherwise use the component of force along the displacement.

3.2.4

Density and pressure

MATTER MAKES A DIFFERENCE



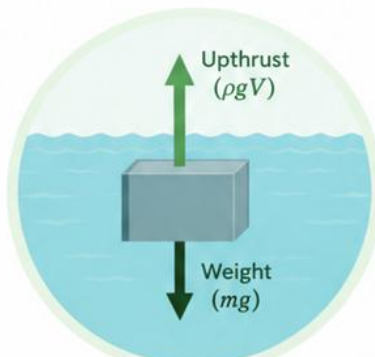
Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) density; $\rho = \frac{m}{V}$
- (b) pressure; $p = \frac{F}{A}$ for solids, liquids and gases
- (c) $p = h\rho g$; upthrust on an object in a fluid; Archimedes' principle.



Objects float because of upthrust.



Fluids exert a pressure that increases with depth.



The same force over a smaller area gives a greater pressure.

SAME PHYSICS.
A BRIGHTER UNDERSTANDING.

Converting area and volume

Choose one answer for each question. Show any conversions in the blank space.

1. An area is 7.0 cm^2 . What is its equivalent in m^2 ?

- A 7.0×10^{-2}
- B 7.0×10^{-4}
- C 4.9×10^{-6}
- D 4.9×10^{-4}

2. A volume is 190 mm^3 . What is its equivalent in m^3 ?

- A 1.9×10^{-8}
- B 1.9×10^{-11}
- C 1.9×10^{-9}
- D 1.9×10^{-7}

3. A 0.50 kN force pushes a nail into wood. The tip area is 0.0010 cm^2 .
What is
the contact pressure?

- A 5 kPa
- B 5 GPa
- C $5 \times 10^8 \text{ Pa}$
- D $5 \times 10^{11} \text{ Pa}$

Density

Density is the mass per unit volume of a substance.

Write the equation for density:

Example: A metal block has a mass of 240 g and a volume of 30 cm^3 .
Calculate its density.

Pressure

Pressure is the force per unit area.

Write the equation for pressure:

Example: A force of 120 N acts on an area of 0.040 m^2 .
Calculate the pressure.

Density and Pressure MCQ Practice

Show your working in the space provided, then choose the best answer.

Q1

Air flows past a turbine. The density of the air is 1.29 kg m^{-3} .
The volume of air flowing past the turbine each second is $1.60 \times 10^4 \text{ m}^3$.
Calculate the mass of air flowing past the turbine each second.

Working:

A.

$1.20 \times 10^4 \text{ kg}$

B.

$1.40 \times 10^4 \text{ kg}$

C.

$2.10 \times 10^4 \text{ kg}$

D.

$2.50 \times 10^4 \text{ kg}$

Q2

A cylindrical section of pipe contains $4.7 \times 10^5 \text{ kg}$ of fluid.
The fluid occupies a cylinder of radius 4.0 m and length 12 m .
Calculate the density of the fluid.

Working:

A.

550 kg m^{-3}

B.

660 kg m^{-3}

C.

780 kg m^{-3}

D.

990 kg m^{-3}

Q3

Find the pressure exerted by a pin head with a cross-sectional area of $2.0 \times 10^{-6} \text{ m}^2$ when a force of 12 N is applied to it.

Working:

A.

130 Pa

B.

6 MPa

C.

8 MPa

D.

13 MPa

Density and pressure practice

Use $g=9.81 \text{ N kg}^{-1}$. Show all unit conversions.

1. Mercury has density $1.4 \times 10^4 \text{ kg m}^{-3}$. Calculate the volume occupied by 2.0 kg of mercury.

2. An iron cube has density 7800 kg m^{-3} and side length 3.0 cm. Calculate its mass, then the pressure it exerts when resting on one full face on a table.

3. A cylindrical pipe of length 3.0 m is completely filled with 500 kg of water of density 1000 kg m^{-3} . Calculate the internal radius of the pipe.

Check for understanding

Density and contact pressure

Choose one answer for each question. Explain why it is correct and why a tempting alternative is wrong.

1. A solid metal sample has mass 350 g and volume 125 cm^3 . What is its density in kg m^{-3} ?

- | | |
|--|-----------------------------------|
| A 2.8 kg m^{-3} | B 2800 kg m^{-3} |
| C $2.8 \times 10^6 \text{ kg m}^{-3}$ | D 280 kg m^{-3} |

Reason:

2. A block exerts pressure p on a horizontal table when its contact area is A . It is turned onto a face of area $A/4$. Its weight is unchanged. What pressure does it now exert?

- | | |
|----------------|---------------|
| A $p/4$ | B p |
| C $16p$ | D $4p$ |

Reason:

3. For a uniform material at fixed temperature, which statements are correct?

1. Cutting a solid block in half halves its density.
2. Density is the mass per unit volume.
3. The same normal force on a smaller area gives greater pressure.

- | | |
|-----------------------|-----------------------|
| A 2 and 3 only | B 1 and 2 only |
| C 1 and 3 only | D 1, 2 and 3 |

Reason:

Fluid pressure (with height)

- Fluid pressure can be calculated using the equation

$$p = \rho h g$$

You may be asked to show where this equation comes from!

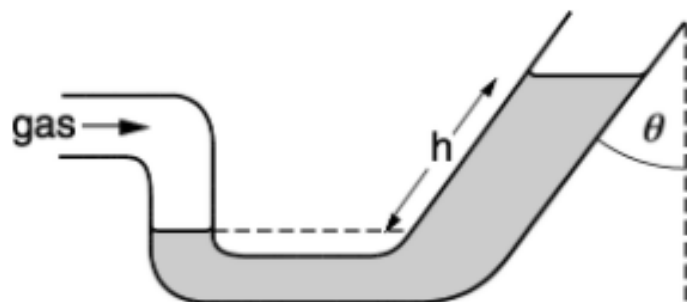


Show where this equation comes from in the space below.

<https://www.youtube.com/watch?v=5EWjIpc0S00>

Gas under pressure is forced into a pipe formed into a U shape bend. A liquid of density ρ is pushed up the right hand side so there is a difference h in the height on each side, measured along the side of the tube.

The pipe on the right hand side is inclined at an angle θ to the vertical and it has a cross sectional area double that on the left side.



What is the pressure of the gas in excess of atmospheric pressure?

- A. $h\rho g$
- B. $2h\rho g$
- C. $h\rho g \cos\theta$
- D. $2h\rho g \cos\theta$

A brick of mass m has sides of lengths a , b and c , where $a < b < c$. The brick is placed on a horizontal table such that the pressure it exerts on the table is a maximum.

What is the maximum pressure p acting on the table?

- A $p = \frac{mg}{ab}$
- B $p = \frac{mg}{ac}$
- C $p = \frac{mg}{bc}$
- D $p = \frac{mg}{abc}$

A block of concrete rests on the ground, as shown in Fig. 7.1.

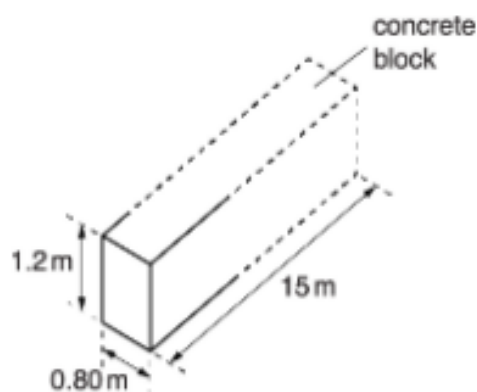


Fig. 7.1

The concrete block is 15 m long, 0.80 m wide and 1.2 m high. The density of concrete is $2.4 \times 10^3 \text{ kg m}^{-3}$. Calculate

i. the weight of the concrete

weight = N [2]

ii. the pressure exerted on the ground by the block of concrete.

pressure = Pa [2]

This question is about helium in the atmosphere of the Earth.

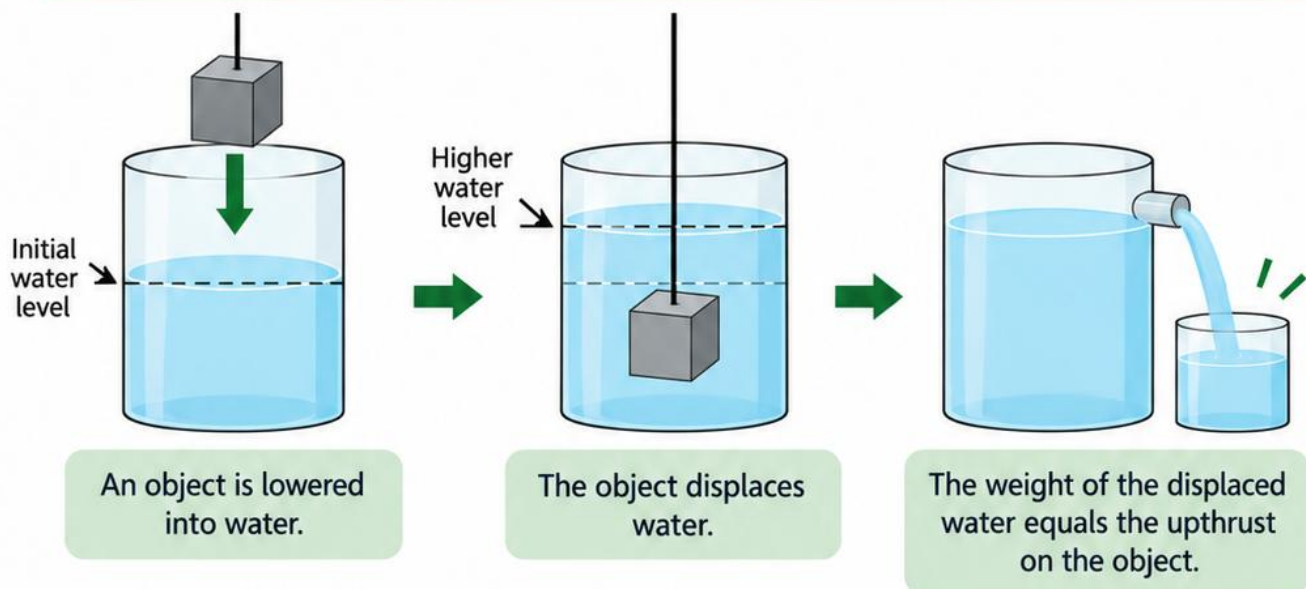
Experiment shows that most of the Earth's atmosphere is contained within a very thin shell around the surface of the Earth. Less than 0.0001% of this is helium.

Assume that the Earth's atmosphere has a constant density ρ of 1.3 kg m^{-3} . The atmospheric pressure at sea level is $1.0 \times 10^5 \text{ Pa}$.

Show that the depth of the atmosphere under these conditions would be about 8 km.

[2]

Archimedes' principle



1 State Archimedes' principle.

2 An object displaces 0.80 kg of water. Calculate the upthrust acting on it. Take $g = 9.81 \text{ N kg}^{-1}$.

Upthrust practice

Remember:

Upthrust = weight of fluid displaced

$$U = \rho Vg$$

U = upthrust (N)

ρ = density of fluid (kg m^{-3})

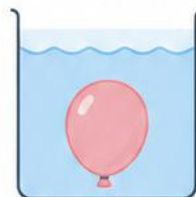
V = volume displaced (m^3)

g = gravitational field strength (N kg^{-1})

1

Water has a density of 1000 kg m^{-3} . A balloon of volume 0.12 m^3 is fully submerged in water. Calculate the upthrust acting on the balloon.

Take $g = 9.81 \text{ N kg}^{-1}$.



Working:

Answer: _____ N

2

Air has a density of 1.3 kg m^{-3} . A balloon of volume 0.21 m^3 is floating stationary in the room. Calculate:

(a) the upthrust acting on the balloon

(b) the total mass of the balloon and the gas inside it

Take $g = 9.81 \text{ N kg}^{-1}$.



Working:

Answers:

(a) Upthrust = _____ N

(b) Total mass = _____ kg

Upthrust challenge

A balloon of volume $2.0 \times 10^{-3} \text{ m}^3$ is fully submerged in water of density 1000 kg m^{-3} . Its total mass, including the enclosed gas, is 0.20 kg . Use $g = 9.81 \text{ N kg}^{-1}$.

1. Calculate the upthrust acting on the balloon.

2. The balloon is released from rest. Calculate its initial acceleration and give its direction. Ignore resistance from the water and treat the volume as constant.

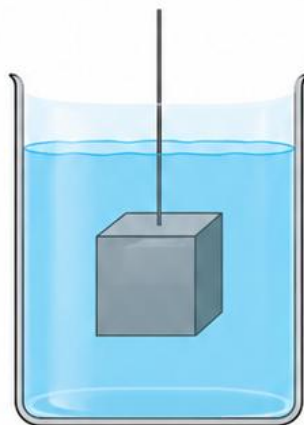
1

A metal block of volume $2.5 \times 10^{-3} \text{ m}^3$ is fully submerged in water of density 1000 kg m^{-3} .

What is the magnitude of the upthrust acting on the block?

Take $g = 9.81 \text{ N kg}^{-1}$.

- A** 2.5 N
- B** 9.8 N
- C** 25 N
- D** 0.25 N



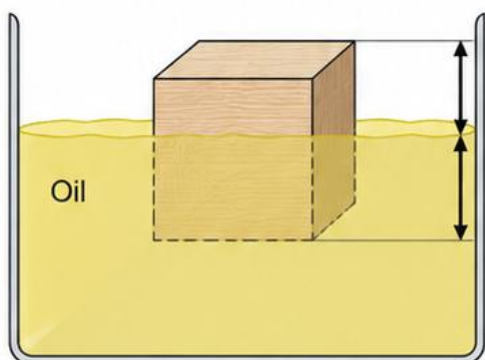
Space for working:

Answer:

2

A solid cube of density 600 kg m^{-3} floats in oil of density 900 kg m^{-3} .

Calculate the percentage of the cube's volume that is above the surface of the oil.



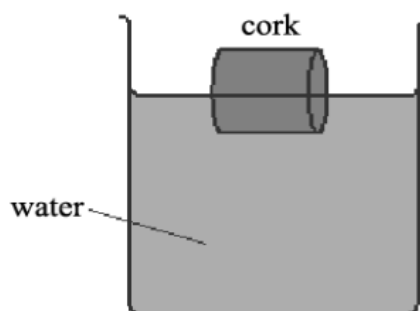
Volume above surface = ?

Volume below surface = ?

Space for working:

Answer: %

- 1 A bottle cork floats on water. It is partially submerged in the water.

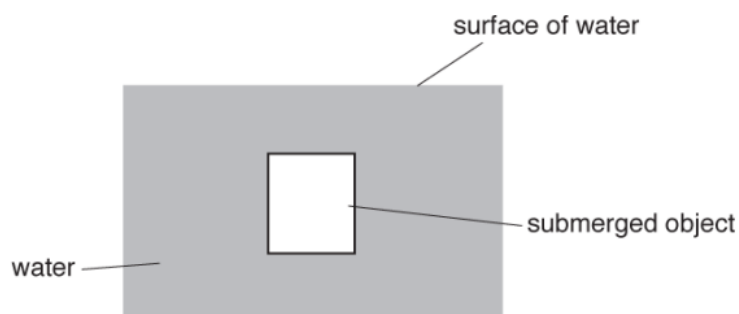


Which of the following statements is / are true?

1. The net force acting on the cork is equal to the weight of the water displaced.
2. The weight of the cork is equal to the upthrust on the cork.
3. The upthrust on the cork is equal to the mass of the water displaced.

- A. 1, 2 and 3
B. Only 2 and 3
C. Only 3
D. Only 2

- 2 The diagram below shows an object submerged in water.



The object is stationary in the water.

Which statement about the upthrust acting on the object is correct?

- A It is zero.
B It is equal to the mass of the object.
C It is equal to the weight of the object.
D It is equal to the volume of the water displaced.

Key ideas

Density

$$\rho = \frac{m}{V}$$

ρ = density (kg m^{-3})

m = mass (kg)

V = volume (m^3)

Pressure (fluids and solids)

$$p = \frac{F}{A}$$

p = pressure (Pa)

F = force (N)

A = area (m^2)

Hydrostatic pressure (in a fluid)

$$p = \rho gh$$

ρ = density of fluid (kg m^{-3})

$g = 9.81 \text{ N kg}^{-1}$

h = depth (m)

Archimedes' principle

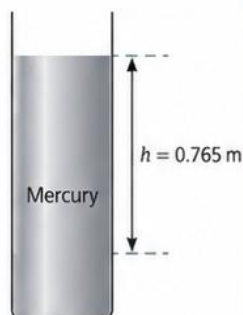
The upthrust on an object in a fluid is equal to the weight of the fluid displaced by the object.

$U = \rho Vg$

U = upthrust (N)

V = volume of fluid displaced (m^3)

- 1** The density of mercury is $1.35 \times 10^4 \text{ kg m}^{-3}$. Calculate the pressure exerted by a column of mercury at a depth of 0.765 m. Take $g = 9.81 \text{ N kg}^{-1}$.



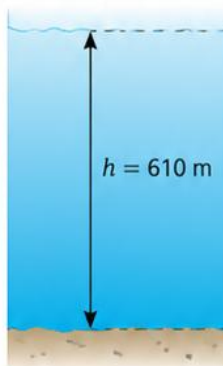
Space for working:

Answer: Pa

- 2** The pressure in water at a depth of 610 m is $6.0 \times 10^6 \text{ Pa}$.

Show that the density of water is roughly $1 \times 10^3 \text{ kg m}^{-3}$.

Take $g = 9.81 \text{ N kg}^{-1}$.

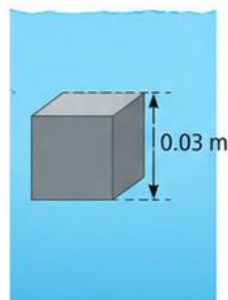


Space for working:

Answer: $\rho \approx$ kg m^{-3}

- 3** State Archimedes' principle and calculate the upthrust acting on a cube of side 0.03 m when it is fully submerged in a fluid of density 890 kg m^{-3} .

Take $g = 9.81 \text{ N kg}^{-1}$.



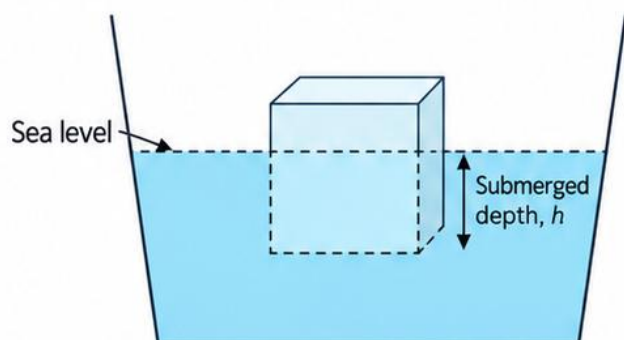
State Archimedes' principle:

.....

Space for working:

Answer: $U =$ N

Iceberg calculations - Extension



Model assumptions

Assume the ice is at rest and is modelled as a cube.

Use Archimedes' principle and take sea water density as 1030 kg m^{-3} and ice density as 910 kg m^{-3} unless otherwise stated.

1 Quick check

A cube of ice is floating in sea water. The cube is modelled as having mass 1875 kg . Calculate the depth of ice beneath the sea level.

A

1.1 m

B

1.3 m

C

2.7 m

D

13 m

Justify your choice briefly.

2 Standard problem

An iceberg is modelled as a cube of side length 1.50 m floating in sea water. Calculate the depth of the iceberg below the sea level.

3 Extension challenge

A cube of frozen liquid with side length 3.0 cm floats in water of density 1000 kg m^{-3} . The cube is submerged to a depth of 2.3 cm . Calculate the mass of the frozen cube.

Check for understanding

Fluid pressure and upthrust

Choose one answer for each question. Explain why it is correct and why a tempting alternative is wrong.

1. A narrow tank and a wide tank contain the same liquid at rest. Both surfaces are open to the atmosphere. Compare the gauge pressures at points 2.0 m below each surface.

- | | |
|-------------------------------------|-----------------------------------|
| A Greater in the narrow tank | B Greater in the wide tank |
| C The same in both tanks | D Zero in both tanks |

Reason: _____

2. In water of constant density, the gauge pressure at depth h is 20 kPa. Atmospheric pressure is 100 kPa. What is the absolute pressure at depth $2h$?

- | | |
|------------------|------------------|
| A 140 kPa | B 40 kPa |
| C 240 kPa | D 120 kPa |

Reason: _____

3. In a liquid of constant density, which statements are correct?

1. Upthrust equals the weight of displaced liquid.
2. Upthrust always equals the object's weight.
3. A rigid, fully submerged object has the same upthrust at greater depth.

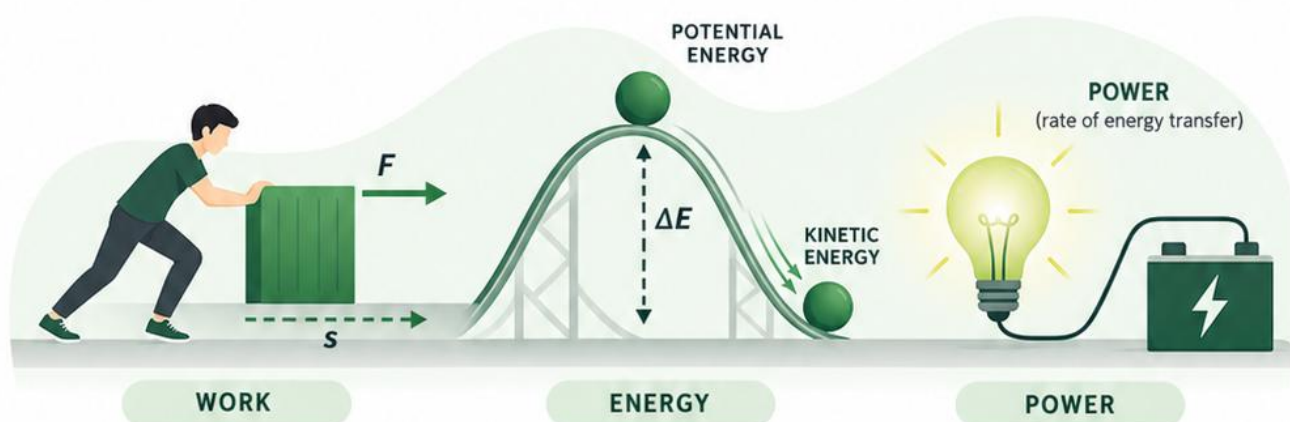
- | | |
|---------------------|-----------------------|
| A 1 only | B 2 and 3 only |
| C 1, 2 and 3 | D 1 and 3 only |

Reason: _____

3.3 Work, energy and power

In physics, the terms work, energy and power have precise meanings. This section explores the link between work done and energy, and shows how the principle of conservation of energy can be applied to a variety of situations.

Energy changes form, but it is always conserved.



3.3.1 Work and conservation of energy

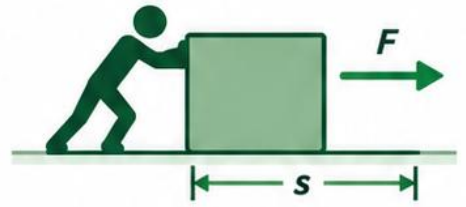


Learning outcomes

By the end of this section, you should be able to:

- (a) describe work done by a force and use the joule (J) as the unit of work/energy
- (b) use the equation $W = F \cdot s \cos \theta$ for work done by a force
- (c) explain the principle of conservation of energy
- (d) identify different forms of energy, and explain how energy is transferred and conserved
- (e) show that the energy transferred is equal to the work done.

Work done



1 State the principle of conservation of energy.

2 Define the term work done.

3 Give an equation for work done.

4 Give the base units of the joule.

Define *work done by a force*.

[1]

A crate is pushed along a rough horizontal surface at a constant speed. State what happens to the work done on the crate.

 In your answer, you should use appropriate technical terms, spelled correctly.

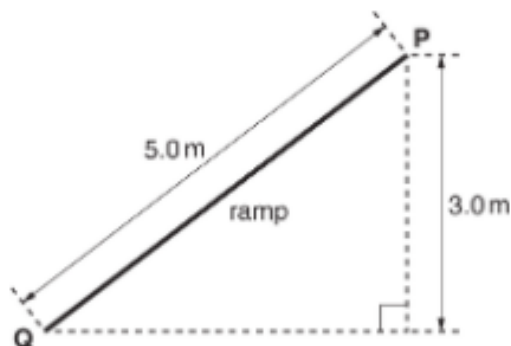
[1]

A force of 12 N moves an object at an angle θ to the force. The object travels 9.6 m and the work done by the force is 52 J.

What is the angle θ ?

- A 1.1°
- B 27°
- C 63°
- D 90°

An object is at the top of a ramp at point P. The gravitational potential energy of the object at P is 100 J. The object is released from rest at P. It travels down the ramp. The kinetic energy of the object at the bottom of the ramp at point Q is 60 J.

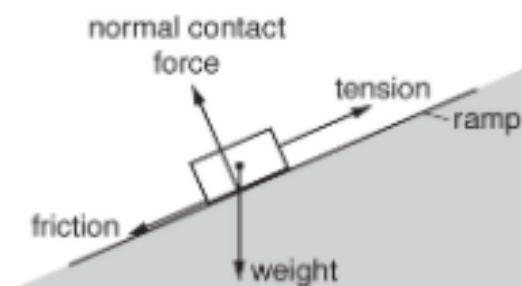


What is the average resistive force acting on the object as it travels down the ramp?

- A 8.0 N
- B 10 N
- C 12 N
- D 20 N

A block moves at **constant** speed up a ramp.

The diagram below shows all the forces acting on the block.



Which force does no work on, or against, the object as it travels up the ramp?

- A weight
- B friction
- C tension
- D normal contact force

Check for understanding

Work and energy transfers

Choose one answer for each question. Explain why it is correct and why a tempting alternative is wrong.

1. A rope pulls a crate with a constant force of 50 N at 30° above the horizontal. The crate moves 4.0 m horizontally. What work does the rope do on the crate?

- | | |
|----------------|----------------|
| A 200 J | B 173 J |
| C 100 J | D 0 J |

Reason: _____

2. A constant frictional force of magnitude 12 N acts opposite to a box's motion. The box moves 3.0 m. What is the work done by friction on the box?

- | | |
|----------------|-----------------|
| A +36 J | B -4.0 J |
| C 0 J | D -36 J |

Reason: _____

3. A box slides horizontally across a rough, level floor. Which statements are correct?

1. One joule is one $\text{kg m}^2 \text{s}^{-2}$.
2. The normal contact force does positive work.
3. Friction transfers energy to thermal stores.

- | | |
|-----------------------|-----------------------|
| A 1 and 3 only | B 1 and 2 only |
| C 2 and 3 only | D 1, 2 and 3 |

Reason: _____

3.3.2 Kinetic and potential energies

Specification points

You should be able to demonstrate and apply your knowledge and understanding of:

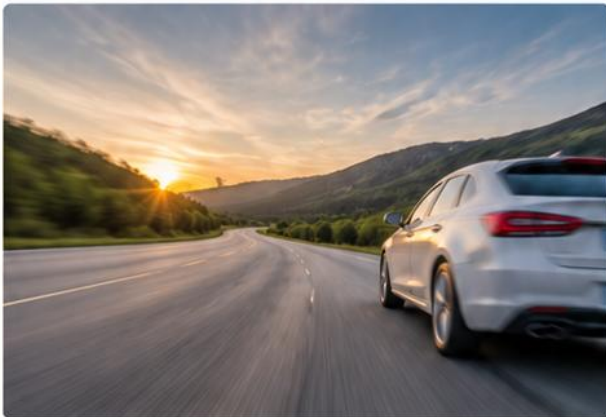
- a** kinetic energy of an object; $E_k = \frac{1}{2}mv^2$
- b** gravitational potential energy of an object in a uniform gravitational field; $E_p = mgh$
- c** the exchange between gravitational potential energy and kinetic energy.

Key ideas

1 Kinetic energy

Kinetic energy is the energy an object has due to its motion.

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



2 Gravitational potential energy

Gravitational potential energy is the energy an object has due to its position in a gravitational field.

$$E_p = mgh$$



Derivation of E_k



Teacher modelling

Derivation of E_{gpe}



Teacher modelling

Energy loss on a slope

Teacher example

A 0.20 kg block starts from rest on a rough straight slope. The vertical drop is 10 m and the distance along the slope is 20 m. It reaches the bottom at 12 m s⁻¹. Use $g=9.81 \text{ N kg}^{-1}$.

Sketch and label the slope. Calculate: (a) GPE lost, (b) final KE, (c) energy dissipated and (d) average frictional force.

Now try these

1. A 0.150 kg particle starts from rest and slides down a slope with a vertical drop of 12 m. Show that its speed would be approximately 15 m s⁻¹ with no energy losses.
2. Its actual final speed is 13.0 m s⁻¹. Calculate the energy dissipated during its descent.
3. The distance along the slope is 24 m. Calculate the average resistive force.
4. Which statement explains the lower speed?
A GPE is destroyed.
B Energy is transferred to thermal energy and sound.
C Friction increases the mass.
D The weight decreases.

Working space:

Work, energy and power

Applying ideas

1

A 20 g bullet is travelling at a velocity of $2.1 \times 10^2 \text{ m s}^{-1}$ before hitting an apple. The velocity of the bullet is measured to be $1.8 \times 10^2 \text{ m s}^{-1}$ when leaving the apple. The apple has a diameter of 8 cm.



a

Calculate the initial kinetic energy of the bullet.

[2 marks]

b

Calculate the work done by the apple on the bullet.

[2 marks]

c

Calculate the (average) force exerted on the bullet by the apple.

[2 marks]

d

Calculate the deceleration experienced by the bullet while in the apple.

[2 marks]

e

Suggest, in terms of energy conversions, why there is a reduction in the velocity of the bullet passing through the apple.

[3 marks]

2

A golfer hits a 50 g ball through short grass towards a hole. The ball leaves the club at a speed of 4.2 m s^{-1} and falls into the hole at a speed of 0.3 m s^{-1} , 5.5 m away.

Calculate the magnitude of the average frictional force acting on the golf ball.



[3 marks]

Gravitational Potential and Kinetic Energy

Starting



Calculate the gain in E_{gpe} of an aeroplane of mass 9.4×10^4 kg as it climbs through a vertical distance of 1500 m.

Securing



A roller coaster cart of mass 500 kg begins at rest, then drops 55 m into a tunnel. Assuming that air resistance is negligible:

- (a) Calculate the initial E_{gpe}
- (b) Calculate the E_k as it enters the tunnel
- (c) Calculate the speed as it enters the tunnel

Extending



Victoria Falls is a waterfall on the Zambezi River on the border of Zambia and Zimbabwe. It has a height of 110 m. Calculate the maximum speed of the water entering the plunge pool at the base of the waterfall and state any assumptions you have made.



Challenging



A bullet of mass 30 g is fired at a block of wood at a speed of 240 m s^{-1} . The bullet penetrates a distance of 8.5 cm into the wood. Calculate the average resistive force exerted on the bullet by the wood block.

The block was resting on a target stand 1.31 m high. Calculate the horizontal distance the block travels before hitting the ground. Assume the block moves off the table at a speed of 12 m s^{-1} .

Working space:

Two unpowered toy cars, **P** and **Q**, are released from rest from **X** and travel down the track to **Y**. Car **P** has twice the mass of car **Q**. There is negligible friction.

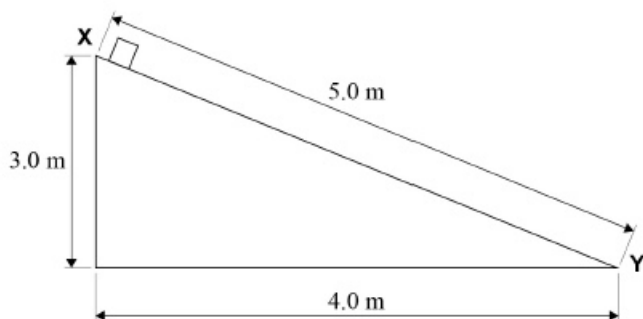


What quantity is the same for car **P** and car **Q**?

- A The gravitational potential energy at **X**. ☐
- B The accelerating force at **X**. ☐
- C The velocity when they arrive at **Y**. ☐
- D The momentum when they arrive at **Y**. ☐

(Total 1 mark)

A mass of 2.5 kg is released from rest at **X** and slides down a ramp, of height 3.0 m, to point **Y** as shown.



When the mass reaches **Y** at the bottom of the ramp it has a velocity of 5.0 m s^{-1} .

What is the average frictional force between the mass and the ramp?

- A 8.5 N ☐
- B 10.6 N ☐
- C 14.7 N ☐
- D 24.5 N ☐

(Total 1 mark)

A roller coaster car is raised to a height of 65 m and released from rest.

What is the maximum possible speed of the car?

- A 11 m s^{-1} ☐
- B 25 m s^{-1} ☐
- C 36 m s^{-1} ☐
- D 130 m s^{-1} ☐

(Total 1 mark)

An electron has speed v . The electron's kinetic energy is doubled.

What is the new speed of the electron?

- A $\frac{v}{\sqrt{2}}$ ☐
- B $\sqrt{2}v$ ☐
- C $2v$ ☐
- D $4v$ ☐

(Total 1 mark)

Objects **P** and **Q** are initially at rest at time $t = 0$

The same resultant force F is applied to **P** and **Q** for time T .

The mass of **P** is 10 times greater than the mass of **Q**.

What is the ratio $\frac{\text{kinetic energy of P}}{\text{kinetic energy of Q}}$?

- A 0.1 ☐
- B 1 ☐
- C 10 ☐
- D 100 ☐

(Total 1 mark)

1(a). Fig. 3.1 shows a stunt rider on a powerful motorbike at X at the top of a ramp.

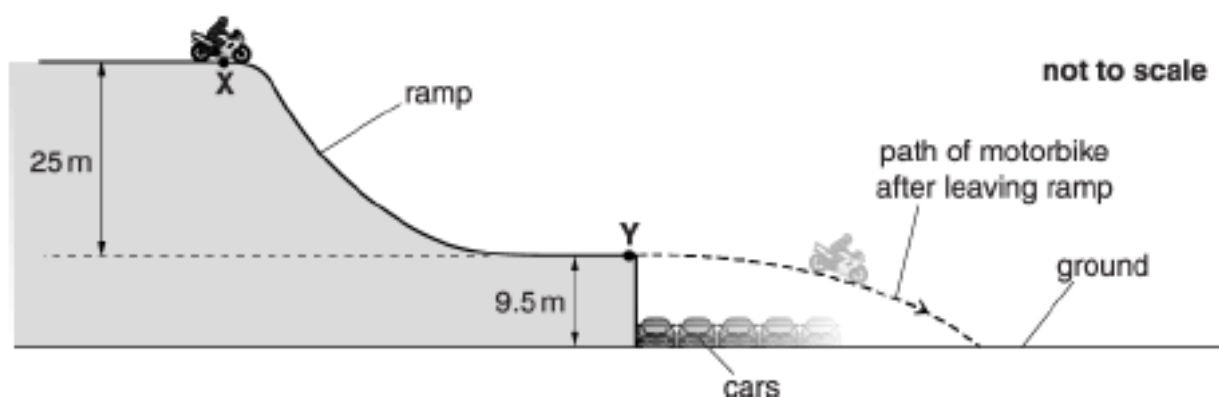


Fig. 3.1

The total mass of motorbike and rider is 190 kg. The height difference between the top and the bottom of the ramp is 25 m. The rider uses the engine to accelerate down the ramp. He leaves the end of the horizontal section of the ramp at Y with a speed of 30 m s^{-1} .

Calculate the loss of gravitational potential energy E_p of the rider and motorbike from X to Y.

$$E_p = \text{-----} \text{ J [1]}$$

(b). Calculate the kinetic energy E_k of the rider and motorbike at Y.

$$E_k = \text{-----} \text{ J [1]}$$

(c). Explain why your answer to (b) is greater than your answer to (a).

[1]

(d). The total distance travelled by the motorbike from X to Y along the ramp is 120 m. Calculate the average accelerating force that the motorbike engine provides along the ramp.

force = _____ N [2]

Check for understanding

Kinetic and gravitational potential energy

Choose one answer for each question. Explain why it is correct and why a tempting alternative is wrong.

1. A particle of mass m travelling at speed v has kinetic energy E . What is the kinetic energy of a particle of mass $2m$ travelling at speed $2v$?

A $2E$

B $4E$

C $8E$

D $16E$

Reason: _____

2. A 2.0 kg block moves down a ramp 5.0 m long, with a vertical drop of 3.0 m . What is its change in gravitational potential energy? Use $g = 9.81\text{ N kg}^{-1}$.

A -98.1 J

B -58.9 J

C $+58.9\text{ J}$

D $+98.1\text{ J}$

Reason: _____

3. At the highest point of a ball launched at 45° above horizontal with no air resistance, which statements are correct?

1. Its vertical velocity is zero.

2. Its kinetic energy is zero.

3. Its total KE + GPE is unchanged.

A 1 only

B 2 and 3 only

C 1, 2 and 3

D 1 and 3 only

Reason: _____

Section

3.3.3 Power

Power describes how quickly energy is transferred or work is done, and links forces, motion and efficiency in real systems.

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) power; the unit watt;

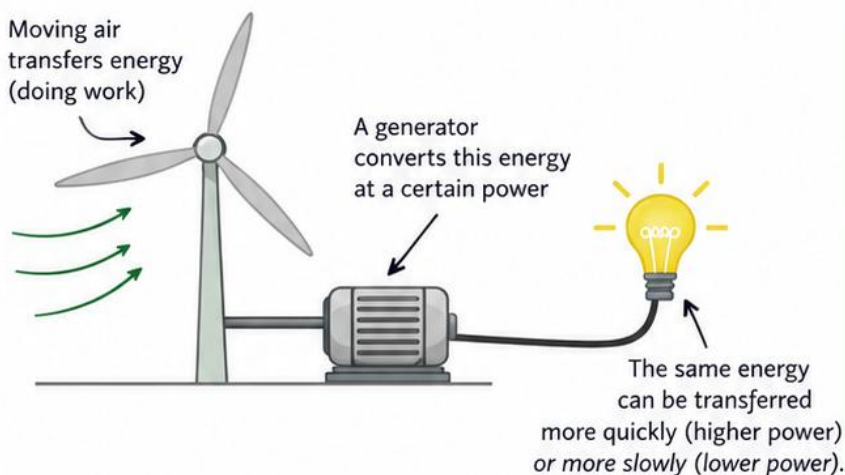
$$P = \frac{W}{t}$$

(b) $P = Fv$

(c) efficiency of a mechanical system;

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

Moving air transfers energy (doing work)



Key idea

Power is the rate of energy transfer.

A larger power means the same amount of energy is transferred in a shorter time.

Deriving a new power equation

1 What is the equation for average speed?

2 What is the equation for work done?

3 Combine these with the expression for power found previously to derive a new power expression:

Step 1:

Start with the expression for power:
Power = work done / time



Step 2:

Substitute the equation for
work done ($W = F \times d$):



Step 3:

Use the equation for average
speed ($v = d / t$):



Step 4:

Final expression for power:

Power = _____

Power practice

1

A **60 kg** person runs up a flight of stairs in a time of **7.2 s**.

The gain in vertical height in this time interval is **5.0 m**.

Calculate the average power developed by the person against gravity.

Use $g = 9.81 \text{ N kg}^{-1}$.

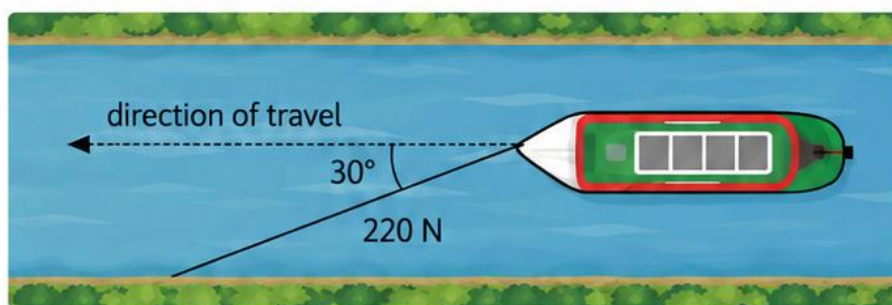
Working space:

2

A canal boat is pulled by a single rope.

The tension in the rope is **220 N**. The rope makes an angle of **30°** to the direction of travel. The speed of the boat is **1.8 m s⁻¹**.

Calculate the power transferred by the component of the tension in the direction of travel.



- A 61 W
- B 200 W
- C 340 W
- D 400 W

Answer:

The engine of a high speed train, travelling at 50 ms^{-1} , delivers a power of 2 MW.

What is the force exerted by the engine?

- A $4 \times 10^4 \text{ N}$
- B $1 \times 10^5 \text{ N}$
- C $4 \times 10^7 \text{ N}$
- D $1 \times 10^8 \text{ N}$

Your answer

A force of 1000 N is needed to lift the hook of a crane at a constant velocity. The crane is then used to lift a load of 10000 N at a velocity of 0.50 ms^{-1} .

How much power does the motor of the crane need to develop to lift the hook and load?

- A 5.0 kW
- B 5.5 kW
- C 20 kW
- D 22 kW

Your answer

An object of mass m is accelerated from rest to a velocity v by a constant resultant force F .

What is the work done on the object during this acceleration?

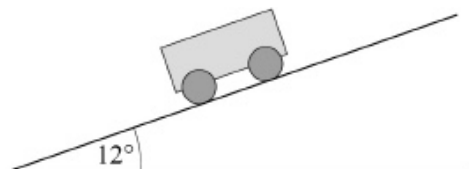
- A $\frac{Fv}{2}$ ☐
- B Fv ☐
- C mv^2 ☐
- D $\frac{mv^2}{2}$ ☐

(Total 1 mark)

A car's engine produces a useful output power of $6.5 \times 10^4 \text{ W}$

The car of mass 950 kg is moving up a hill at a steady speed.

The slope of the hill is 12° to the horizontal. Resistive forces on the car are negligible.



What is the steady speed of the car?

- | | |
|---------------------------------|--------------------------|
| A 7.0 m s^{-1} | ☐ |
| B 12 m s^{-1} | ☐ |
| C 34 m s^{-1} | ☐ |
| D 68 m s^{-1} | ☐ |

(Total 1 mark)

A car exerts a driving force of 500 N when travelling at a constant speed of 72 km h^{-1} on a level track. What is the work done in 5 minutes?

- | | |
|--------------------------------------|--------------------------|
| A $3.0 \times 10^6 \text{ J}$ | ☐ |
| B $2.0 \times 10^6 \text{ J}$ | ☐ |
| C $2.0 \times 10^5 \text{ J}$ | ☐ |
| D $1.1 \times 10^5 \text{ J}$ | ☐ |

(Total 1 mark)

Which of the following is **not** a unit of power?

- | | |
|---|--------------------------|
| A N m s^{-1} | ☐ |
| B J s | ☐ |
| C W | ☐ |
| D $\text{kg m}^2 \text{ s}^{-3}$ | ☐ |

(Total 1 mark)

Power

Starting



Calculate the power of a lamp that transfers 240 J in 30 s.

Securing



Calculate the energy transferred by a 2.0 kW motor in a time of 1 minute.

Extending



An aircraft has four jet engines, each producing 210 kN of thrust.

Calculate the total power output of the engines when the aircraft is in level flight and travelling at a constant velocity of 250 m s^{-1} .

Challenging



A car of mass 1200 kg reaches a speed of 18 m s^{-1} in 20 s from rest.

Calculate the average rate of work done on the car, and state any assumptions you have made during your calculations.

Working space:

The ratio of useful output energy or power to the total input energy or power.

The efficiency of a device is the ratio of the useful output to the total input.

$$\eta = \frac{E_{out}}{E_{in}}$$

$$\eta = \frac{P_{out}}{P_{in}}$$

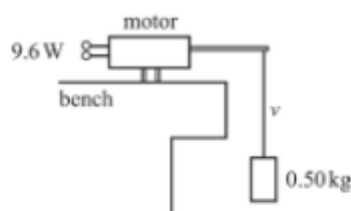
The efficiency, η , has no units and is usually written as a decimal or a percentage.

A lamp has an efficiency of 0.05 for converting electrical energy to electromagnetic energy. Calculate the energy transferred as EM radiation by a 60 W lamp over the course of 1 hour.

Show your working:

[illegible]

A small electric motor is 20% efficient. Its input power is 9.6 W when it is lifting a mass of 0.50 kg at a steady speed v .



What is the value of v ?

- A. 0.39 m s^{-1}
- B. 2.0 m s^{-1}
- C. 2.8 m s^{-1}
- D. 3.8 m s^{-1}

A crane raises a mass of 3000 kg through a height of 12 m in 40 seconds with an efficiency of 60%.

Calculate the total input energy to the crane.

total input energy J [2]

An electric motor of input power 100 W raises a mass of 10 kg vertically at a steady speed of 0.5 m s^{-1} . What is the efficiency of the system?

- | | | |
|----------|------|-----------------------|
| A | 5% | ☐ |
| B | 12% | ☐ |
| C | 50% | ☐ |
| D | 100% | ☐ |

(Total 1 mark)

Efficiency

A motor is used to lift a 120 kg load vertically through a height of 8.0 m in 20 s . The motor operates at a constant input power of 6.0 kW .

- (a) Calculate the useful output energy transferred to the load.
- (b) Hence determine the efficiency of the motor.



Answer space: % [3]

Work done and braking

A car of mass $1.2 \times 10^3\text{ kg}$ is travelling at 25 m s^{-1} on a level road. The driver brakes and brings the car to rest in a distance of 60 m . It is known that only 70% of the car's initial kinetic energy is dissipated in the brakes. The rest is lost to air resistance.

- (a) Calculate the initial kinetic energy of the car.
- (b) Determine the total work done on the car by the brakes.
- (c) Calculate the average braking force provided by the brakes.



Answer space: N [4]

Efficiency

Starting



The lamp mentioned previously had an efficiency of 5% for converting electrical energy into electromagnetic radiation.

What other energy transfers occur in the lamp?

Securing



A small 3.5 W electric motor raises a 15 N load through a vertical height of 1.4 m in 30 s.

Calculate the efficiency of the motor.

Assume the load is lifted at constant velocity.

Extending



A box of mass 750 g is pulled up a smooth slope at 30° to the horizontal at a constant velocity.

- (a) Calculate the tension, T , in the rope pulling the box.
- (b) The tension is provided by a motor at the top of the ramp, 12 m from the base. If the box is initially 4.5 m from the base of the ramp, calculate the power rating of the motor if the box moves to the top of the ramp in 13 s.

The motor has an efficiency, η , of 0.30.

Challenging



Dinorwig power station generates 600 MW of electrical power.

Water falls 50 m before passing through its turbines.

The transfer of gravitational potential energy to electrical energy is 40% efficient.

Calculate the rate of water flow through the turbines in $\text{m}^3 \text{s}^{-1}$.

Take the density of water to be 1000 kg m^{-3} and $g = 9.81 \text{ N kg}^{-1}$.

Working space:

1. Fig. 6.1 shows an electric crane lifting a mechanical digger.

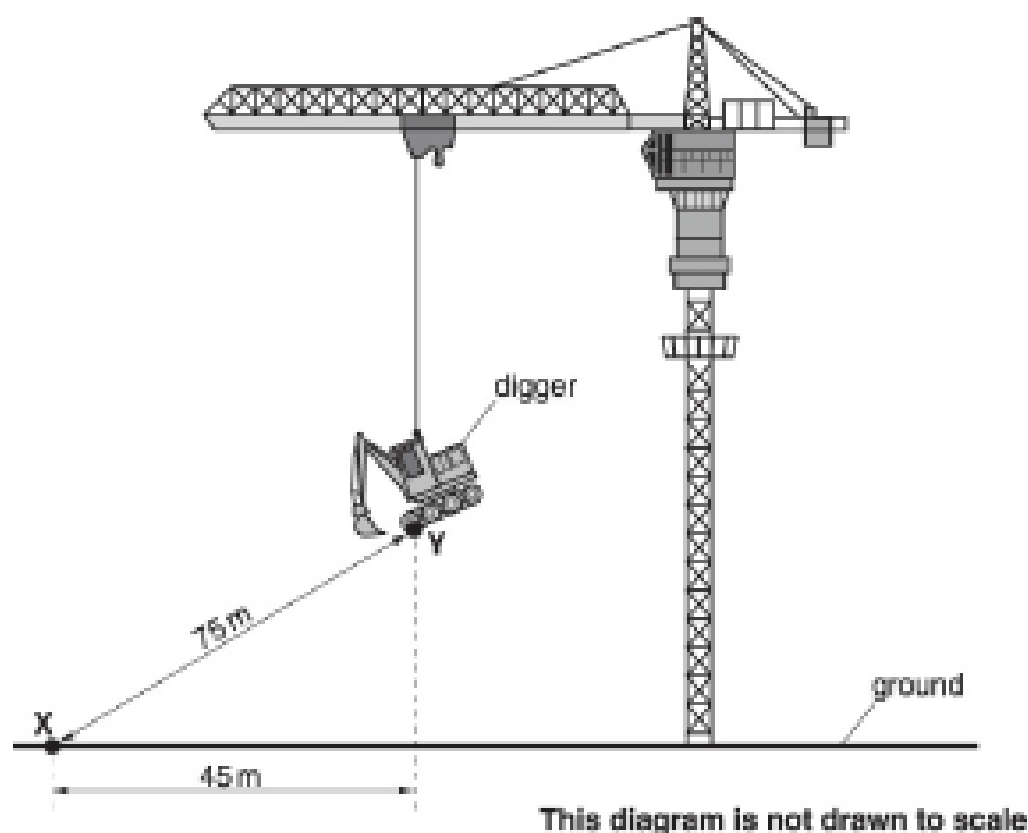


Fig. 6.1

The mass of the digger is 5200 kg. The crane takes 1.5 minutes to lift the digger from X to Y.

- (i) Calculate the rate of work done to lift the digger from X to Y.

rate of work done = J s^{-1} [3]

- (ii) The total input power to the motors of the crane is 170 kW. Calculate the efficiency of the lifting operation.

Check for understanding

Power and efficiency

Choose one answer for each question. Explain why it is correct and why a tempting alternative is wrong.

1. A car travels along a level road at a steady speed of 20 m s^{-1} . Its engine provides a driving force of 300 N parallel to the motion, balancing resistance. What useful mechanical power does the engine deliver?

- | | |
|-----------------|----------------|
| A 6.0 kW | B 0 W |
| C 15 W | D 600 W |

Reason: _____

2. A motor has useful mechanical output power 120 W and efficiency 30% . What is its electrical input power during steady operation?

- | | |
|----------------|----------------|
| A 36 W | B 400 W |
| C 120 W | D 156 W |

Reason: _____

3. For a motor with only electrical input, operating steadily:

1. One watt is one joule per second.
 2. Useful output power can exceed input power.
 3. Transferring the same energy in less time increases average power.
- Which statements are correct?

- | | |
|-----------------------|-----------------------|
| A 1 and 2 only | B 2 and 3 only |
| C 1 and 3 only | D 1, 2 and 3 |

Reason: _____

Review exam questions

The mass of an ostrich is 130 kg. It can run at a maximum speed of 70 kilometres per hour.

- i. Calculate the maximum kinetic energy of the ostrich when it is running.

kinetic energy = J [3]

- ii. Scientists have recently found fossils of a prehistoric bird known as Mononykus.

Fig. 1.1 shows what the Mononykus would have looked like.



Fig. 1.1

According to a student, the Mononykus looks similar to our modern day ostrich. The length, height and width of the Mononykus were all **half** that of an ostrich.

Estimate the mass of the Mononykus. Explain your reasoning.

.....
.....
.....
..... [2]

Define *work done by a force*.

.....
..... [1]

Define the *watt*.

..... [1]

Fig. 1.1 shows a train of mass $1.9 \times 10^5 \text{ kg}$ travelling at 61 km h^{-1} along a level track.



Fig. 1.1

i. Show that the train is travelling at about 17 ms^{-1} .

[1]

ii. The brakes of the train are applied and the train is brought to rest in a distance of 310 m. Calculate

1. the initial kinetic energy E_k of the train

$$E_k = \dots\dots\dots \text{J [2]}$$

2. the average deceleration a of the train

$$a = \dots\dots\dots \text{ms}^{-2} [3]$$

3. the average braking force F on the train.

$$F = \dots\dots\dots \text{N [2]}$$

Fig. 1.2 shows a similar train travelling at 61 km h^{-1} up an incline.



Fig. 1.2

The brakes of the train are applied with the same average braking force.
State and explain how the distance that the train travels, from when the brakes are applied until the train stops, compares with when the train is travelling on level track.

[2]

A solid wooden sphere of density 650 kg m^{-3} has a diameter of 2.8 cm.

i. Describe and explain how the student can measure precisely the diameter of the sphere.

.....

.....

.....

..... [2]

ii. Show that the mass of the sphere is 0.0075 kg.

[2]

iii. The sphere is pushed below the surface of water as shown in Fig. 3.

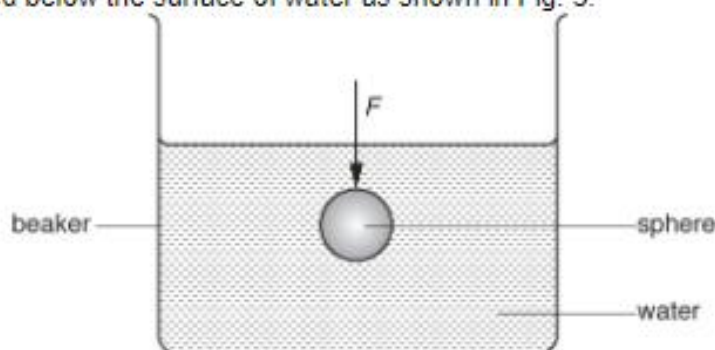


Fig. 3

Determine the force F that needs to be applied to the sphere to keep the wooden sphere stationary in this position.

density of water = 1000 kg m^{-3}

$F = \text{.....} \text{ N}$ [2]

What is the approximate average kinetic energy of a cyclist in a race?

A 10 J ☐

B 10 kJ ☐

C 10 MJ ☐

D 10 TJ ☐

(Total 1 mark)

A car of mass 1000 kg accelerates uniformly from rest to a speed of 25.0 m s^{-1} in 50.0 s.
The car is travelling along a horizontal road.

What is the average useful power output of the car over this period?

A 0.50 kW ☐

B 2.00 kW ☐

C 6.25 kW ☐

D 12.5 kW ☐

(Total 1 mark)

An electric motor is used to lift a weight of 4.0 N through a vertical height of 0.90 m in 1.8 s. The efficiency of the motor is 20%.

What is the electrical power supplied to the motor?

- A** 0.40 W
- B** 2.0 W
- C** 3.6 W
- D** 10 W

Your answer

[1]

The watt is the SI unit for power.

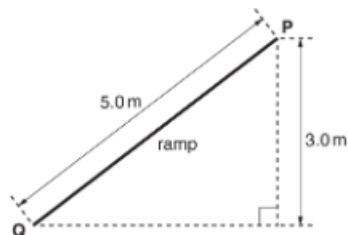
Which is the correct definition for the watt? A watt is

- A** the rate of work done.
- B** the work done per second.
- C** a joule per second.
- D** a joule per unit time.

Your answer

[1]

An object is at the top of a ramp at point **P**. The gravitational potential energy of the object at **P** is 100 J. The object is released from rest at **P**. It travels down the ramp. The kinetic energy of the object at the bottom of the ramp at point **Q** is 60 J.



What is the average resistive force acting on the object as it travels down the ramp?

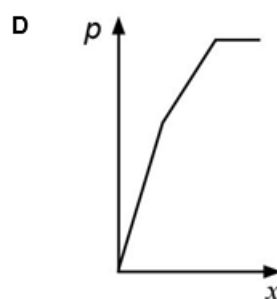
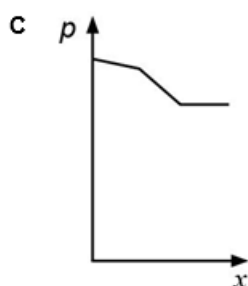
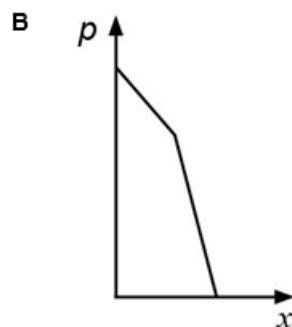
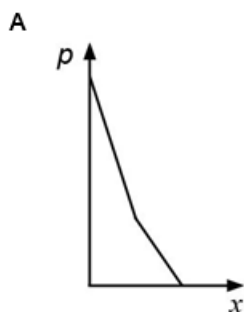
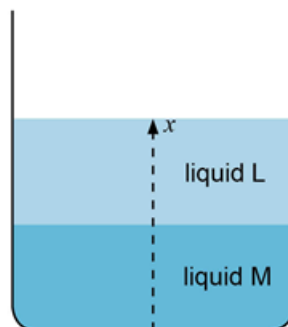
- A** 8.0 N
- B** 10 N
- C** 12 N
- D** 20 N

Your answer

[1]

24. A tall container which is open to the atmosphere contains a layer of liquid **L**, floating on liquid **M**, which has a density which is twice that of liquid **L**.

Which graph shows how the pressure in the liquid, p , at a point varies with its height, x , above the base of the container?



Here p is gauge pressure (pressure above atmospheric pressure).
Choose one graph and explain your answer.

18. The engine of a high speed train, travelling at 50 ms^{-1} , delivers a power of 2 MW.

What is the force exerted by the engine?

- A $4 \times 10^4 \text{ N}$
- B $1 \times 10^5 \text{ N}$
- C $4 \times 10^7 \text{ N}$
- D $1 \times 10^8 \text{ N}$

Your answer

A

19. A force of 1000 N is needed to lift the hook of a crane at a constant velocity. The crane is then used to lift a load of 10000 N at a velocity of 0.50 ms^{-1} .

How much power does the motor of the crane need to develop to lift the hook and load?

- A 5.0 kW
- B 5.5 kW
- C 20 kW
- D 22 kW

Your answer

B

Consolidation 1: Density and pressure

Specification focus: 3.2.4(a), 3.2.4(b) and the fluid-pressure equation in 3.2.4(c).

Specification confidence check				
Specification point	RAG			Next step
3.2.4(a) density; $\rho = m / V$	R	A	G	
3.2.4(b) pressure; $p = F / A$ for solids, liquids and gases	R	A	G	
3.2.4(c) $p = h\rho g$	R	A	G	

Key equations

$\rho = m / V$

$p = F / A$

$\Delta p = \rho gh$

$1 \text{ Pa} = 1 \text{ N m}^{-2}$

Method and unit checks

- ☐ Convert mass to kg and dimensions to metres before using SI equations.
- ☐ Area conversions are squared; volume conversions are cubed.
- ☐ For $p = \rho gh$, h is the vertical depth in the fluid.
- ☐ Use $\Delta p = \rho gh$ when referring to the pressure increase due to a fluid column.

Mixed questions

1

A metal block has dimensions $0.12 \text{ m} \times 0.08 \text{ m} \times 0.05 \text{ m}$ and mass 3.84 kg . Calculate its density.

2

The block rests on its largest face. Calculate the pressure it exerts on the table. Take $g = 9.81 \text{ N kg}^{-1}$.

3

Mercury has density $1.35 \times 10^4 \text{ kg m}^{-3}$. Calculate the pressure increase at a depth of 0.765 m .

4

The pressure increase in water at a depth of 610 m is $6.0 \times 10^6 \text{ Pa}$. Show that the density is approximately $1.0 \times 10^3 \text{ kg m}^{-3}$.

Examiner trap

Do not treat cm^2 or cm^3 as though they convert like length. Convert squared and cubed units correctly.

Consolidation 2: Upthrust and Archimedes' principle

Specification focus: the upthrust and Archimedes' principle content in 3.2.4(c).

Specification confidence check				
Specification point	RAG			Next step
3.2.4(c) upthrust on an object in a fluid	R	A	G	
3.2.4(c) Archimedes' principle	R	A	G	

Key equations
$$U = \rho Vg$$
$$W = mg$$
floating at rest: $U = W$
$$\rho_{\text{fluid}} V_{\text{sub}} = \rho_{\text{object}} V_{\text{object}}$$

Buoyancy checks
☐ Archimedes' principle: upthrust equals the weight of fluid displaced.
☐ V in $U = \rho Vg$ is the volume of fluid displaced, not always the total object volume.
☐ A fully submerged object displaces its full volume; a floating object does not.
☐ If the object accelerates vertically, use resultant force = upthrust – weight with a stated positive direction.

Mixed questions

1

A $2.5 \times 10^{-3} \text{ m}^3$ block is fully submerged in water of density 1000 kg m^{-3} . Calculate the upthrust.

2

A cube of density 600 kg m^{-3} floats in oil of density 900 kg m^{-3} . Calculate the percentage of the cube above the surface.

3

Air has density 1.3 kg m^{-3} . A balloon of volume 0.21 m^3 floats stationary. Calculate the upthrust and the total mass of the balloon plus gas.

4

A 2.5 cm^3 sphere of density 7800 kg m^{-3} is released fully submerged in water. Calculate its initial acceleration and state the direction.

Examiner trap
Upthrust equals the weight of displaced fluid. It equals the object's weight only when the vertical forces balance.

Consolidation 3: Work and conservation of energy

Specification focus: all points in 3.3.1 Work and conservation of energy.

Specification confidence check

Specification point	RAG	Next step
3.3.1(a) work done by a force; the unit joule	R A G	
3.3.1(b) $W = Fx \cos \theta$ for work done by a force	R A G	
3.3.1(c) the principle of conservation of energy	R A G	
3.3.1(d) energy in different forms; transfer and conservation	R A G	
3.3.1(e) transfer of energy is equal to work done	R A G	

Key equations

$W = Fs \cos \theta$
 $\Delta E = W$
 $1 \text{ J} = 1 \text{ N m}$
energy transferred = work done

Energy language to use

- ☐ θ is the angle between the force and the displacement.
- ☐ A force perpendicular to the displacement does zero work.
- ☐ Resistive forces transfer mechanical energy to thermal energy and other stores.
- ☐ Energy is conserved; do not describe energy as being destroyed.

Mixed questions

- 1 An 18 N force acts at 35° to the direction of motion while an object moves 6.0 m. Calculate the work done by the force.
- 2 A resistive force of 1.2 N acts opposite to the motion over 4.0 m. State the sign of the work done by the force and calculate the energy dissipated.
- 3 A 30 g bullet travelling at 240 m s^{-1} is brought to rest over 8.5 cm in wood. Calculate the average resistive force.
- 4 An object loses 100 J of GPE while moving 5.0 m down a ramp and gains 60 J of KE. Calculate the average resistive force.

Examiner trap

Do not use $W = Fs$ unless force and displacement are parallel. Use the component of force in the direction of displacement.

Consolidation 4: kinetic and potential energy

Circle R, A or G for each specification point and record your next step.

Specification point	R/A/G	Next step
3.3.2(a) Kinetic energy	R A G	
3.3.2(b) GPE in a uniform field	R A G	
3.3.2(c) Exchange between GPE and KE	R A G	

Key equations and checks

$E_k = \frac{1}{2}mv^2$; $E_p = mgh$; $\Delta E_p = mg\Delta h$

No losses: $\Delta E_k = -\Delta E_p$

KE depends on speed squared. Use vertical height changes for GPE.
With no losses, the decrease in GPE equals the increase in KE.
A shortfall in KE represents energy transferred to other stores.

Mixed questions

1. An aircraft of mass 9.4×10^4 kg climbs 1500 m. Calculate its gain in GPE.
2. A cart starts from rest and drops 55 m. Neglect resistance and calculate its speed at the bottom.
3. A 2.5 kg block starts from rest and descends a 5.0 m ramp with vertical drop 3.0 m. It reaches 5.0 m s^{-1} . Calculate the energy dissipated and the average resistive force.
4. An electron's initial speed is v . Its KE doubles. Express its new speed in terms of v .

Consolidation 5: power and efficiency

Circle R, A or G for each specification point and record your next step.

Specification point	R/A/G	Next step
3.3.3(a) Power and the watt	R A G	
3.3.3(b) Power and force: $P = Fv$	R A G	
3.3.3(c) Efficiency of a mechanical system	R A G	

Key equations and checks

$P = W/t = E/t$; $P = Fv$ (parallel force)

$\eta = \text{useful output} / \text{total input}$

1 W = 1 J s⁻¹. Convert kW and MW to W. Use the force component along the motion.
Efficiency has no units; multiply the fraction by 100% for a percentage.
Divide useful output by total input; do not invert the fraction.

Mixed questions

1. A lamp transfers 240 J in 30 s. Calculate its power.
2. A train delivers useful power 2.0 MW at 50 m s⁻¹. Calculate the driving force.
3. A motor has input power 3.5 W and raises a 15 N load through 1.4 m in 30 s. Calculate its efficiency.
4. A hydroelectric station supplies 600 MW of electrical power. Water falls 50 m and the process is 40% efficient. Calculate the volume flow rate. Take density 1000 kg m⁻³ and g=9.81 N kg⁻¹.

Additional note space



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