Week 9

A-Level Physics

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

A-Level Physics   Name: ________________   Score: ______

1. A force of 10 N pushes a box 3.0 m in the direction of the force. How much work is done?

   ________________ J

2. A 2.0 kg book is lifted 5.0 m. How much gravitational PE does it gain? (Use $g = 9.81\ \frac{\mathrm{m}}{\mathrm{s}^2}$.)

   ________________ J

3. A force acting at right angles to the motion does how much work?

   ☐ zero

   ☐ positive work

   ☐ negative work

   ☐ the most work

4. A 4.0 kg trolley moves at $3.0\ \frac{\mathrm{m}}{\mathrm{s}}$. What is its kinetic energy?

   ________________ J

5. Friction on a sliding object does negative work.

   ☐ True   ☐ False

6. As a ball rolls down a frictionless ramp, its gravitational PE turns mainly into:

   ☐ kinetic energy

   ☐ elastic potential energy

   ☐ thermal energy

   ☐ electrical energy

7. Energy cannot be created or destroyed, only ______ from one form to another.

   ____

8. Kinetic energy written in terms of momentum p is:

   ☐ $\frac{p^2}{2m}$

   ☐ $\frac{p}{2m}$

   ☐ $\frac{2m}{p^2}$

   ☐ $\frac{mp^2}{2}$

9. A machine takes in 200 J and gives out 60 J of useful energy. What is its efficiency (in %)?

   ________________ %

10. A block slides into a spring on a frictionless surface. At greatest compression its kinetic energy has all become ______ potential energy.

   ____

A-Level Physics

1. **30 J**

   Force is along the motion ($\theta = 0$), so $W = Fs = 10 \times 3.0 = 30$ J.

2. **98.1 J**

   $\Delta E_P = mg\Delta h = 2.0 \times 9.81 \times 5.0 \approx 98$ J.

3. **zero**

   $W = Fs\cos 90° = 0$. The normal contact force on a car on a flat road does no work.

4. **18 J**

   $E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 4.0 \times 3.0^2 = 18$ J.

5. **True**

   Friction points opposite to the motion ($\theta = 180°$), so $W = -Fs$ — it takes energy away.

6. **kinetic energy**

   With no friction, all the lost GPE becomes kinetic energy: $mgh = \frac{1}{2}mv^2$.

7. **transferred**

   That is conservation of energy — the total in a closed system stays the same.

8. $\dfrac{p^2}{2m}$

   From $p = mv$ and $E_K = \frac{1}{2}mv^2$, substituting $v = p/m$ gives $E_K = \dfrac{p^2}{2m}$.

9. **30 %**

   $\dfrac{60}{200} \times 100\% = 30\%$. The other 140 J is wasted, mostly as heat.

10. **elastic**

    KE $\rightarrow$ elastic PE $= \frac{1}{2}kx^2$ at the point of greatest compression, then back to KE as the spring pushes it off.

A-LEVEL PHYSICS • EXERCISE SHEET

5.1 Energy conservation

Name: ____________ Class: ________ Date: __________ **Total: 26 marks**

KEY WORDS power 功率 • work 功 • efficiency 效率 • energy 能量 • conservation of energy 能量守恒

Objective

Build the skills to answer exam questions on **energy conservation** — work, the conservation principle, efficiency and power.

You must be able to:

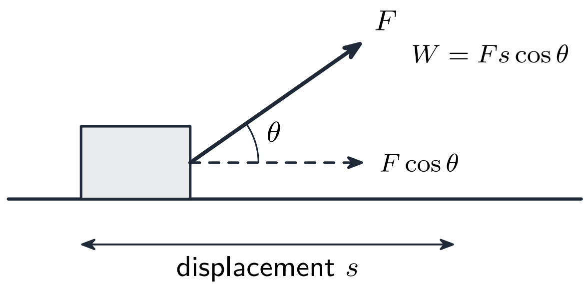
- use **work done** $= Fs\cos\theta$
- apply **conservation of energy** (e.g. GPE $\rightarrow$ KE)
- use **efficiency** and **power** ($P = W/t$ and $P = Fv$)

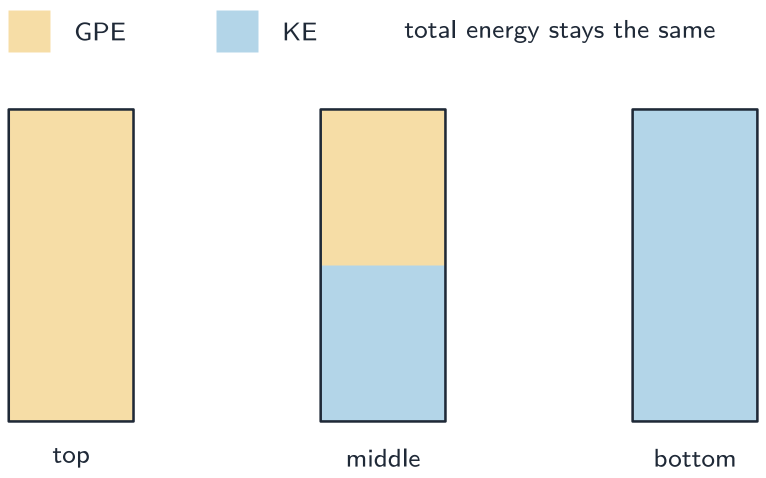
1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Work done

Work is done when a force moves along its own line: $W = Fs\cos\theta$. Only the component **along** the displacement does work:





Energy is conserved as it transfers

- $\theta = 0$: $W = Fs$ (max); $\theta = 90°$: $W = 0$ (e.g. the normal force on a flat road); $\theta = 180°$: $W = -Fs$ (e.g. friction).

■ Conservation of energy

Energy is never made or destroyed. On a **smooth** ramp, GPE → KE:

$$mgh = \tfrac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh}.$$

■ Efficiency and power

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}}, \qquad P = \frac{W}{t}, \qquad P = Fv.$$

$P = Fv$ comes from $P = W/t = Fs/t = F(s/t) = Fv$.

■ Efficiency, and where the wasted energy goes

Efficiency compares what you **want** with what you **paid for**, as energies or as powers:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} = \frac{\text{useful power output}}{\text{total power input}}$$

It has **no unit**, and it can be written as a decimal or a percentage — but never above 1. Two habits win the marks:

- **Work out the useful output first**, from what the machine actually achieves (mgh for a lift, Fs for a drag, $\tfrac{1}{2}mv^2$ for a launch).
- **The wasted energy is input minus useful output**, and the exam wants to know *where it went*: thermal energy in the motor windings and bearings, sound, and in a lift the kinetic energy left over if it does not stop.

Worked example. A pump raises 600 kg of water through 12 m in 30 s, drawing 3.0 kW.

$$P_{\text{useful}} = \frac{mgh}{t} = \frac{600 \times 9.81 \times 12}{30} = 2354\ \text{W}, \qquad \text{efficiency} = \frac{2354}{3000} = 0.78$$

2 Practice

Now apply the methods above.

2.1 Define the **work done** by a force. [1]

2.2 A child pulls a sledge 5.0 m with a 20 N force at 60° to the ground. Find the **work done**. [2]

2.3 Define **power** and give its unit. [1]

2.4 State the **principle of conservation of energy**. [1]

3 Exam-style questions

3.1 A force acts at 90° to the direction of motion. The work it does is: [1]

- **A** maximum
- **B** Fs
- **C** zero
- **D** negative

3.2 A ball is released from rest at the top of a **smooth** ramp 1.2 m high. Calculate its speed at the bottom. ($g = 9.81$ m s^{-2}.) [3]

3.3 A motor lifts a 50 kg load through 8.0 m in 10 s.

(a) Calculate the **useful power** output. [2]

(b) If the input power is 500 W, calculate the **efficiency**. [2]

3.4 Derive $P = Fv$ from $P = W/t$. [2]

3.5 A crane is used on a building site.

(a) **Define** the **work done** by a force. [1]

(b) A block of mass m is raised vertically at constant speed through a height Δh. **Derive** an expression, in terms of m and Δh, for the change in gravitational potential energy ΔE_{P} of the block. State the meaning of any other symbol you use. [2]

(c) The crane raises a steel beam of mass 450 kg at constant speed through a vertical height of 24 m, taking 40 s.

(i) **Calculate** the work done on the beam. [2]

(ii) **Calculate** the useful output power of the crane. [2]

(iii) The input power to the crane is 3.6 kW. **Calculate** its efficiency. [2]

(iv) **Determine** the energy wasted during the 40 s, and **state** one form it takes. [2]

Solutions

2.1 Work = force × displacement **in the direction of the force** ($W = Fs\cos\theta$).

2.2 $W = Fs\cos\theta = 20 \times 5.0 \times \cos 60° = 50$ J.

2.3 Power is the **work done (energy transferred) per unit time**, unit **watt** (W = J s^{-1}).

2.4 Energy cannot be **created or destroyed**, only **transferred** from one form to another; the total energy of a closed system is constant.

3.1 **C** — zero.

3.2 $mgh = \frac{1}{2}mv^2$; $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 1.2} = \sqrt{23.5} = 4.9$ m s^{-1}.

3.3 (a) useful work = $mgh = 50 \times 9.81 \times 8.0 = 3924$ J; $P = W/t = 3924/10 = 392$ W.
(b) efficiency = $392/500 = 0.78 = 78\%$.

3.4 $P = W/t = Fs/t$; since $s/t = v$, $P = Fv$.

3.5 (a) The product of the force and the **displacement in the direction of the force**.
(b) Raising the block at constant speed needs an upward force equal to its weight, mg, where g is the acceleration of free fall; the gain in potential energy is the work done by that force, so $\Delta E_{\mathrm{P}} = mg\Delta h$.
(c)(i) $W = mg\Delta h = 450 \times 9.81 \times 24 = 1.1 \times 10^5$ J.
(c)(ii) $P = \dfrac{W}{t} = \dfrac{1.06 \times 10^5}{40} = 2.6 \times 10^3$ W.
(c)(iii) efficiency $= \dfrac{P_{\text{useful}}}{P_{\text{input}}} = \dfrac{2650}{3600} = 0.74$, i.e. 74%.
(c)(iv) input energy $= 3600 \times 40 = 1.44 \times 10^5$ J, so wasted $= 1.44 \times 10^5 - 1.06 \times 10^5 = 3.8 \times 10^4$ J; it becomes **thermal energy** in the motor windings, gearbox and cable (also some sound).

19 A sailboat is pushed by the wind at a constant velocity *v* across a lake.

The force of the wind and the velocity of the sailboat are in the same direction.

Which additional information is required to determine the work done per unit time by the wind acting on the sailboat?

A the force exerted by the wind

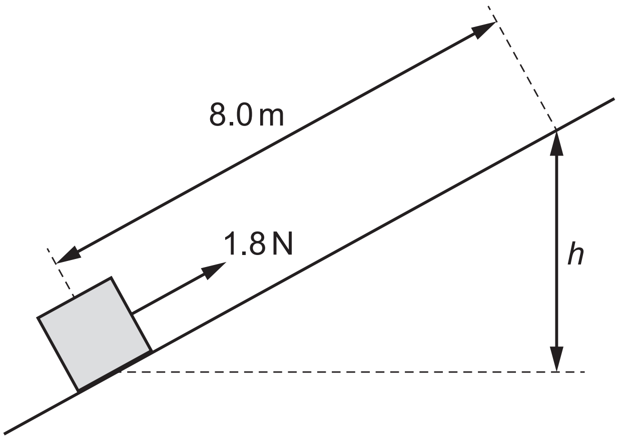
B the distance travelled by the sailboat per unit time

C the total energy input to the sailboat by the wind

D the weight of the sailboat

A-Level Physics: **w25 12**

19 The diagram shows a block on a slope.



A constant force of 1.8 N in a direction parallel to the slope is exerted on the block. This causes the block to move along the slope at a constant speed.

The block moves a distance of 8.0 m along the slope and gains height *h*. The work done against the frictional force acting on the block is 4.8 J.

The weight of the block is 4.0 N.

What is the value of *h*?

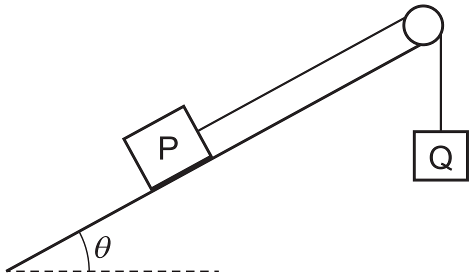
A 1.2 m **B** 2.4 m **C** 3.6 m **D** 4.8 m

20 The motor of a crane lifts a load of mass 600 kg. The load rises vertically at a constant speed of 12 m per minute.

What is the useful power output of the motor?

A 0.12 kW **B** 1.2 kW **C** 7.2 kW **D** 71 kW

16 The diagram shows a block P of mass M connected by a string over a frictionless pulley to a block Q of mass m.



Block P moves up the slope with a constant velocity v. The slope is at angle θ to the horizontal.

The acceleration of free fall is g.

The resistive forces on the blocks are negligible.

Which expressions give the energy transferred per unit time to block P?

1 mgv

2 $Mgv\sin\theta$

3 $(M + m)gv$

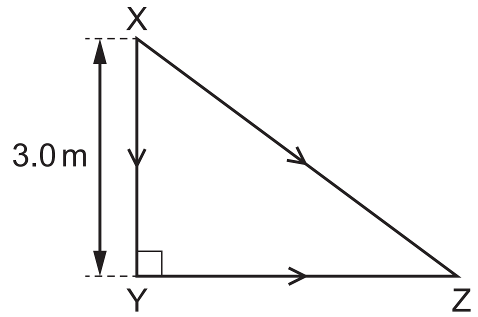
A 1 and 2 **B** 1 only **C** 2 and 3 **D** 2 only

18 The total energy supplied to an electric motor is E. Energy Q is wasted and the remaining energy does useful work.

What is the efficiency of the motor?

A $\dfrac{Q}{E}$ **B** $\left(\dfrac{Q}{E}\right) - 1$ **C** $1 - \left(\dfrac{Q}{E}\right)$ **D** $\dfrac{(1 - Q)}{E}$

18 The points X, Y and Z are on a rough, horizontal surface.



A box P is pushed across the surface from X to Y and then from Y to Z.

The distance from X to Y is 3.0 m. The work done against the frictional force in moving the box from X to Y is 150 J.

The work done against the frictional force in moving the box from Y to Z is 200 J.

An identical box Q is pushed in a straight line from X to Z.

The magnitude of the frictional force between the boxes and the surface is constant.

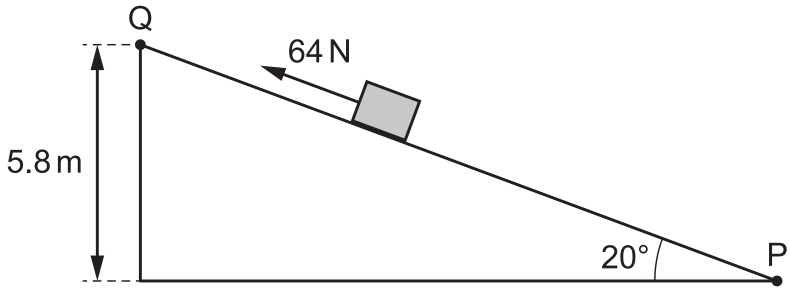
How much extra work is done against the frictional force in moving P than Q?

A 100 J **B** 250 J **C** 350 J **D** 600 J

19 A box of mass 4.9 kg is pushed at a constant velocity from point P at the bottom of an inclined plane to point Q at the top.

The box is pushed by a force of 64 N acting parallel to the slope.

The slope is inclined at an angle of 20° to the horizontal and the box moves through a vertical height of 5.8 m.



What is the work done against the frictional force acting on the block between P and Q?

A 280 J **B** 810 J **C** 960 J **D** 1100 J

20 Which expression gives the efficiency of a system?

A $\dfrac{\text{total energy input}}{\text{useful energy output}}$

B $\dfrac{\text{useful energy output + wasted energy output}}{\text{total energy input}}$

C $\dfrac{\text{useful energy output}}{\text{total energy input}}$

D $\dfrac{\text{wasted energy output}}{\text{total energy input}}$

A-Level Physics: **s25 13**

17 An electric motor uses 1.7 kW of power when operating normally.

The efficiency of the motor is 53%.

What is the useful output power of the motor?

A 0.032 kW **B** 0.90 kW **C** 3.2 kW **D** 90 kW

A-Level Physics: **s25 14**

14 In which situation is work done on an object?

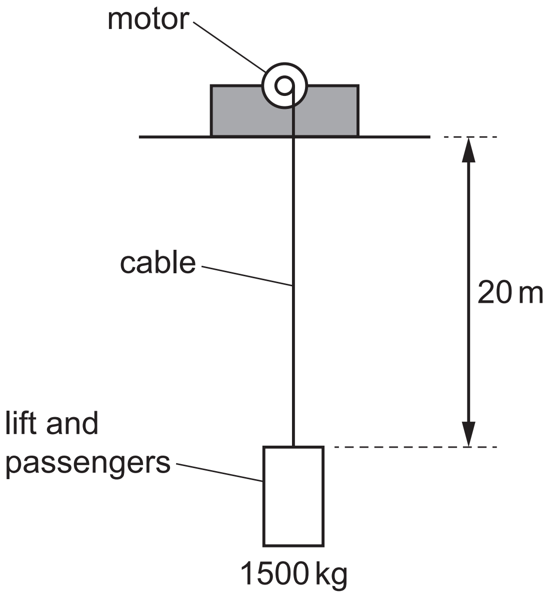
A The object slides with a constant velocity along a horizontal frictionless surface in a vacuum.

B A person holds the object at arm’s length and at a fixed height above the ground.

C A person pushes the object up a frictionless ramp.

D The stationary object floats partially submerged in water.

15 An electric motor operating a lift has an output power of 20 kW.



The lift and passengers have a combined mass of 1500 kg. The motor raises the lift at constant speed through a distance of 20 m.

How long does it take?

A 6 s **B** 15 s **C** 30 s **D** 60 s

3 **(a)** State what is meant by the work done by a force.

....

.... [1]

(b) A block of mass m is raised vertically at constant speed. The vertical height gained by the block is Δh, as shown in Fig. 3.1.

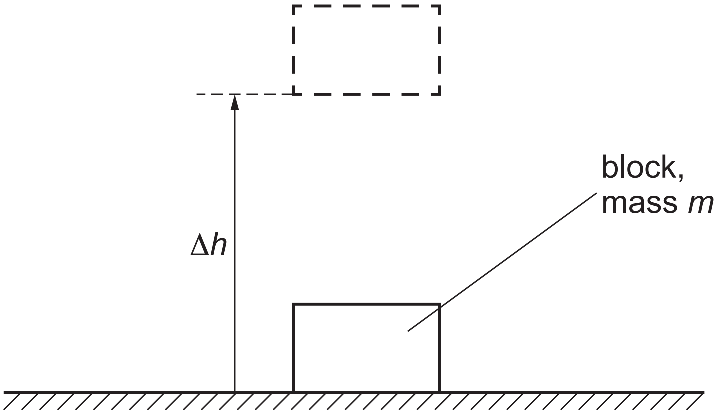


Fig. 3.1

Derive an expression, in terms of m and Δh, for the change in gravitational potential energy ΔE_P of the block. State the meaning of any other symbols you use.

[2]

(c) An electric motor has an input power of 900 W. The motor takes 1.0 minute to lift a load of weight 240 N at constant speed through a vertical height of 150 m. Resistive forces are negligible.

(i) Show that the work done by the motor on the load in 1.0 minute is 36 kJ.

[1]

(ii) Determine the useful output power of the motor.

power = ... W [2]

(iii) Use your answer in **(c)(ii)** to determine the efficiency of the motor.

efficiency = ... [2]

(iv) Some of the power wasted in the motor is dissipated by the resistance of its coil. This dissipated power is 280 W.

The coil of the motor is made from wire of total length 23 m. The wire has a cross-sectional area of $2.6 \times 10^{-8}\,m^2$ and is made from metal of resistivity $1.7 \times 10^{-8}\,\Omega\,m$.

Calculate the current in the coil.

current = ...A [3]

[Total: 11]

5.2 Gravitational potential energy and kinetic energy

Name: ______ Class: ______ Date: ______ **Total: 34 marks**

KEY WORDS energy 能量 • kinetic energy 动能 • gravitational potential energy 重力势能 • mass 质量 • work 功

Objective

Build the skills to answer exam questions on **gravitational potential energy and kinetic energy** — the formulae, their derivations, and energy exchange.

You must be able to:

- use $\Delta E_{\mathrm{P}} = mg\Delta h$ and derive it from $W = Fs$
- use $E_{\mathrm{K}} = \frac{1}{2}mv^2$ and derive it from the equations of motion
- solve problems where GPE and KE exchange

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ GPE change

Lifting mass m slowly through height Δh needs an upward force mg, so the work done (= GPE gained) is

$$\Delta E_{\mathrm{P}} = W = (mg)(\Delta h) = mg\Delta h.$$

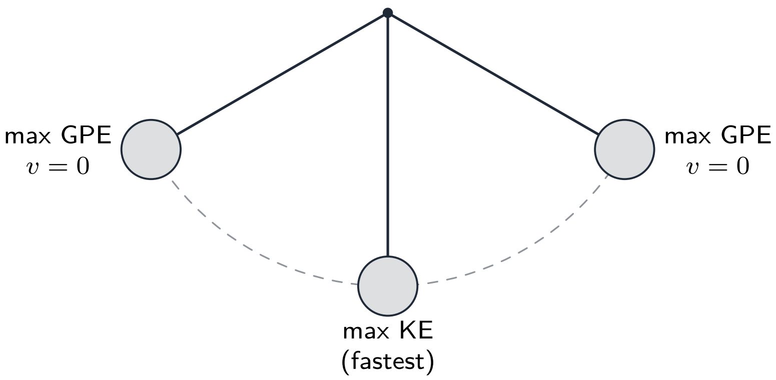
■ Kinetic energy

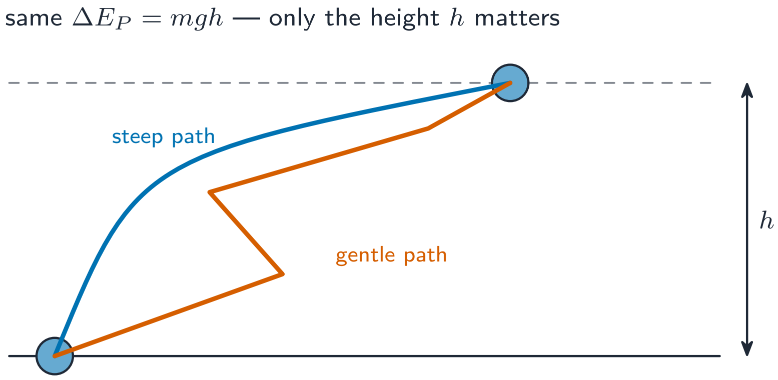
A force F accelerates a mass from rest to speed v over distance s. With $u = 0$, $v^2 = 2as$, so $s = v^2/2a$, and

$$E_{\mathrm{K}} = W = Fs = (ma)\frac{v^2}{2a} = \tfrac{1}{2}mv^2.$$

■ Energy exchange (pendulum)

A pendulum bob trades GPE and KE: **max GPE** (and $v = 0$) at the ends, **max KE** at the bottom:





GPE depends only on height, not the path

Energy is conserved: $mgh = \frac{1}{2}mv^2$, so the bob's speed at the bottom is $v = \sqrt{2gh}$.

■ Energy accounting in a chain of transfers

The hardest energy questions are not one formula: they follow the energy through **several** stores and ask you to keep a running total. A falling block that lands on a spring is the standard case:

$$E_{\text{elastic, max}} = E_{\text{K on contact}} + \Delta E_{\text{P during compression}}$$

The second term is easy to forget — the block keeps falling *while* it compresses the spring, so it loses **more** potential energy after contact.

Two more results the exam builds on top:

- the **area under a force-compression graph** is the elastic potential energy, so for a spring obeying Hooke's law $E = \frac{1}{2}F_0 x_0$, which gives $F_0 = \dfrac{2E}{x_0}$;
- at maximum compression the spring pushes up with F_0 while the weight still pulls down, so the **resultant** force is $F_0 - mg$ and the acceleration is $\dfrac{F_0 - mg}{m}$ — large, upward, and the moment the block starts back up.

2 Practice

Now apply the methods above.

2.1 Write the formula for **GPE change** and for **kinetic energy**. [2]

2.2 Find the **kinetic energy** of a 1200 kg car moving at 15 m s^{-1}. [2]

2.3 Find the **GPE gained** by a 2.0 kg book lifted 1.5 m ($g = 9.81$ m s^{-2}). [2]

2.4 At the **bottom** of a pendulum swing, which energy is at a maximum? [1]

3 Exam-style questions

3.1 An object's speed **doubles**. Its kinetic energy: [1]

- **A** doubles
- **B** halves
- **C** becomes four times larger
- **D** stays the same

3.2 Derive $E_K = \frac{1}{2}mv^2$ using the equations of motion. [3]

3.3 A 0.50 kg ball is dropped from a height of 1.8 m. Calculate its speed just before it hits the ground (ignore air resistance). [3]

3.4 A pendulum bob is released from a point 0.20 m above its lowest point. Calculate its **maximum speed**. [2]

3.5 A 0.20 kg ball is dropped from a height of 1.6 m and rebounds to a height of 1.2 m. Calculate the energy **transferred to other forms** during the bounce. [3]

3.6 A vertical spring stands on a horizontal surface with its lower end fixed. Its mass is negligible. A block of mass 4.0 kg falls onto the spring and is brought to rest as the spring compresses. The block has kinetic energy 72 J at the instant it touches the spring.

(a) **Calculate** the speed of the block as it touches the spring. [2]

(b) While the spring compresses, the gravitational potential energy of the block falls by a further 12 J. **Show that** the maximum compression x_0 of the spring is about 0.31 m. [2]

(c) All the energy lost by the block becomes elastic potential energy in the spring. **De-**

termine the maximum elastic potential energy stored. [1]

(d) The spring obeys Hooke's law, so the force it exerts is proportional to the compression. **Show that** the maximum force F_0 the spring exerts on the block is about 540 N. [2]

(e) At maximum compression, **determine**

(i) the resultant force on the block, [2]

(ii) the acceleration of the block. [2]

(f) **Sketch** a graph to show how the **kinetic energy** of the block varies with the compression of the spring, from the instant of contact to maximum compression. **Label** both axes. [2]

(g) The same block is dropped from a greater height onto the same spring. **Explain** why the maximum compression is greater, and why the maximum acceleration is greater too. [2]

Solutions

2.1 $\Delta E_P = mg\Delta h$; $E_K = \frac{1}{2}mv^2$.

2.2 $E_K = \frac{1}{2}(1200)(15)^2 = 1.35 \times 10^5$ J.

2.3 $\Delta E_P = mg\Delta h = 2.0 \times 9.81 \times 1.5 = 29$ J.

2.4 **Kinetic energy**.

3.1 **C** — KE $\propto v^2$, so doubling v makes KE four times larger.

3.2 Work done $W = Fs = mas$; with $u = 0$, $v^2 = 2as \Rightarrow s = v^2/2a$; $W = ma \cdot \dfrac{v^2}{2a} = \frac{1}{2}mv^2 = E_K$.

3.3 $\frac{1}{2}mv^2 = mgh$; $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 1.8} = 5.9$ m s^{-1}.

3.4 $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.20} = 2.0$ m s^{-1}.

3.5 GPE before $= mgh_1 = 0.20 \times 9.81 \times 1.6 = 3.1$ J; GPE after $= mgh_2 = 0.20 \times 9.81 \times 1.2 = 2.4$ J; energy transferred $= 3.1 - 2.4 = 0.79$ J.

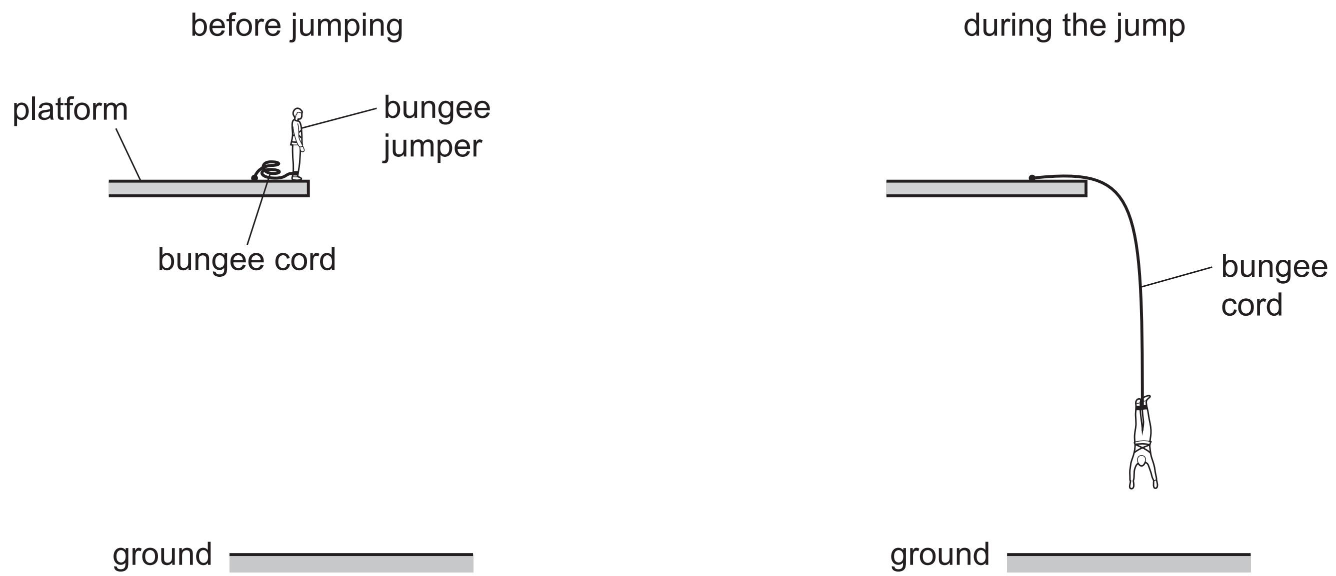
3.6 (a) $E_K = \frac{1}{2}mv^2$, so $72 = \frac{1}{2}(4.0)v^2$; $v = \sqrt{36} = 6.0$ m s^{-1}.
(b) The block falls a further x_0 while compressing the spring, so $\Delta E_P = mgx_0$; $x_0 = \dfrac{12}{4.0 \times 9.81} = 0.31$ m.
(c) All of it goes into the spring: $72 + 12 = 84$ J.
(d) The area under the force-compression graph is the energy stored, and for a straight line that area is a triangle: $E = \frac{1}{2}F_0x_0$; $F_0 = \dfrac{2 \times 84}{0.306} = 5.5 \times 10^2$ N.
(e)(i) The spring pushes **up** with F_0 and the weight pulls **down**: weight $= 4.0 \times 9.81 = 39$ N; resultant $= 549 - 39 = 5.1 \times 10^2$ N, upwards.
(e)(ii) $a = \dfrac{F}{m} = \dfrac{510}{4.0} = 1.3 \times 10^2$ m s^{-2}, upwards — about 13 times g.
(f) Axes labelled *kinetic energy / J* against *compression / m*; a curve starting at 72 J when the compression is zero and falling to zero at $x_0 = 0.31$ m, getting steeper as the spring force grows.
(g) A greater drop height gives the block **more kinetic energy** at contact, so more energy must be stored in the spring; since $E = \frac{1}{2}kx^2$, a larger E needs a larger compression x_0. The spring force is proportional to the compression, so F_0 is larger too, and $a = \dfrac{F_0 - mg}{m}$ therefore rises with it.

17 An object with a mass of 100 g falls a vertical distance of 10 m.

What is the change in the gravitational potential energy of the object?

A 1 J **B** 10 J **C** 100 J **D** 10 000 J

18 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



NOT TO SCALE

When the jumper makes the jump, his initial gravitational potential energy relative to the ground is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

A on the platform before the jump

B on the way down before the cord has started to extend

C on the way down as he decelerates

D at the bottom of the jump when he is stationary

17 A student attempts to derive the formula for kinetic energy E_K. She begins by considering an object of mass m that is initially at rest. A constant force F applied to the object causes it to accelerate to final velocity v in displacement s. The kinetic energy gained by the object is equal to the work done on the object by the force F.

Which equation does the student **not** need in order to derive the formula for E_K?

A $F = ma$ **B** $W = Fs$ **C** $E = \frac{1}{2}Fs$ **D** $v^2 = u^2 + 2as$

18 A ball falls towards the ground from point X. Point X is 2.4 m above the ground.

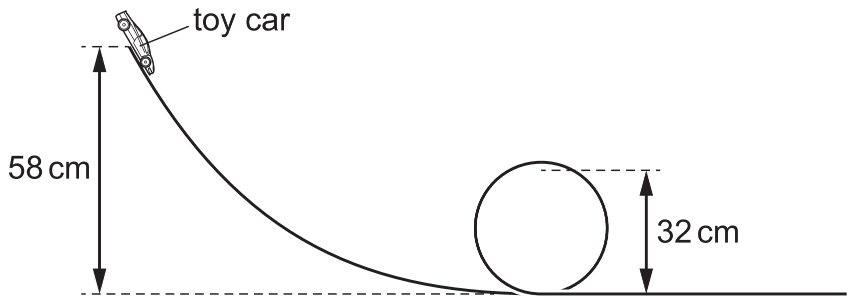
The ball rebounds from the ground and rises to point Y. Point Y is 1.8 m above the ground.

A single value of the change in height Δh is used to calculate the change in gravitational potential energy of the ball from X to Y.

What is the magnitude of Δh?

A 0.6 m **B** 1.8 m **C** 2.4 m **D** 4.2 m

17 A toy car travels around a vertical loop track.



The toy car is released from rest at a height of 58 cm above the bottom of the vertical loop.

The car is at a height of 32 cm when it is at the top of the vertical loop.

Assume that no resistive forces act on the car.

What is the speed of the car at the top of the vertical loop?

A $0.87\,\text{m}\,\text{s}^{-1}$ **B** $2.3\,\text{m}\,\text{s}^{-1}$ **C** $2.5\,\text{m}\,\text{s}^{-1}$ **D** $3.4\,\text{m}\,\text{s}^{-1}$

19 An object travels between two points. The change in gravitational potential energy ΔE_p of the object is given by

$$\Delta E_p = mg\Delta h$$

where m is the mass of the object, Δh is its change in height and g is the acceleration of free fall.

What is a necessary condition in order for the above equation to be valid?

A The object must have a constant acceleration of $9.81\,\text{m}\,\text{s}^{-2}$.

B The object must be travelling in a uniform gravitational field.

C The object must be travelling only in a vertical direction.

D The resultant force on the object must be equal to its weight.

17 An object is falling in a uniform gravitational field.

Which two quantities are sufficient to calculate the change in gravitational potential energy?

A mass and acceleration of free fall

B mass and change in vertical displacement

C weight and acceleration of free fall

D weight and change in vertical displacement

A-Level Physics: **s25 12**

18 A ball of mass 1.2 kg travels horizontally at a speed of $3.0\,\text{m}\,\text{s}^{-1}$.

The ball hits a cushion and comes to rest over a horizontal distance of 0.020 m.

What is the work done by the cushion on the ball to bring the ball to rest?

A 0.24 J **B** 1.8 J **C** 5.4 J **D** 11 J

A-Level Physics: **s25 13**

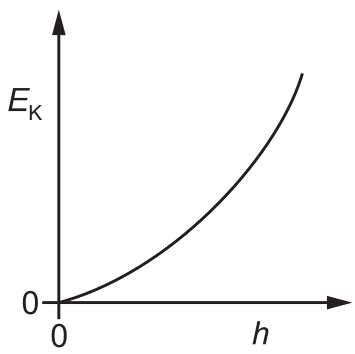
18 A ball is released from rest and falls vertically to the ground.

The kinetic energy E_K of the ball varies as the height h of the ball above the ground changes.

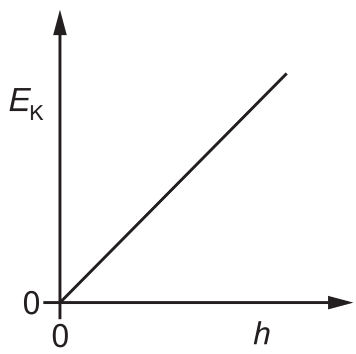
Air resistance is negligible.

Which graph shows the variation of E_K with h?

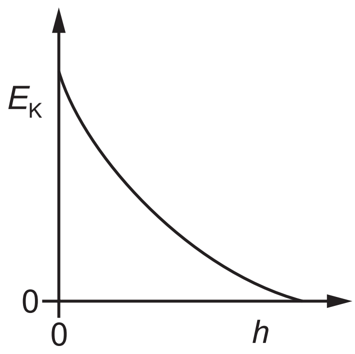
A



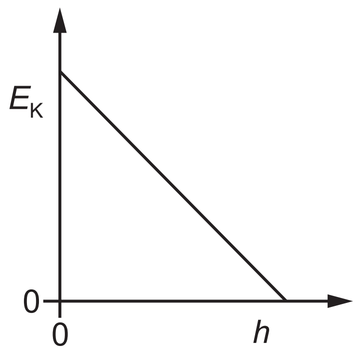
B



C



D



19 An object travelling with a speed of $10\,\mathrm{m\,s^{-1}}$ has kinetic energy of 1500 J.

The speed of the object is increased to $40\,\mathrm{m\,s^{-1}}$.

What is the new kinetic energy of the object?

A 4500 J **B** 6000 J **C** 24 000 J **D** 1 350 000 J

3 The lower end of a vertical spring is fixed to a horizontal surface, as shown in Fig. 3.1.

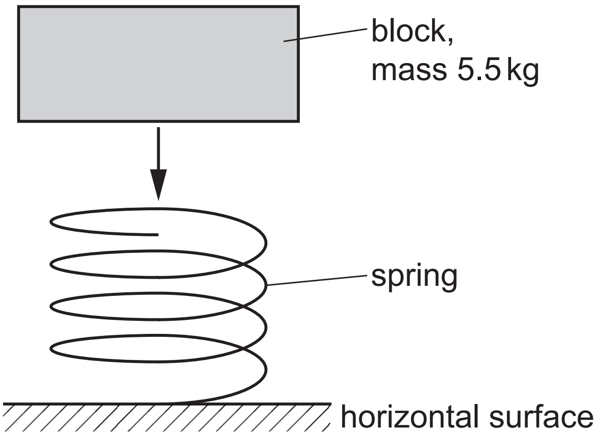


Fig. 3.1

The mass of the spring is negligible. A block of mass 5.5 kg drops vertically onto the spring and is brought to rest as the spring is compressed.

(a) The block has kinetic energy 110 J as it makes contact with the spring.

Calculate the speed of the block as it makes contact with the spring.

speed = ... $m\,s^{-1}$ [2]

(b) The gravitational potential energy of the block decreases by 20 J as the spring is compressed to its maximum compression x_0.

Show that x_0 is 0.37 m.

[2]

(c) Assume that, as the spring compresses, all of the energy lost by the block is converted into the elastic potential energy of the spring.

Use the data from **(a)** and **(b)** to determine the maximum elastic potential energy of the spring.

Show your working.

maximum elastic potential energy = ... J [1]

(d) The variation of the force F acting on the spring with the compression x of the spring is shown in Fig. 3.2.

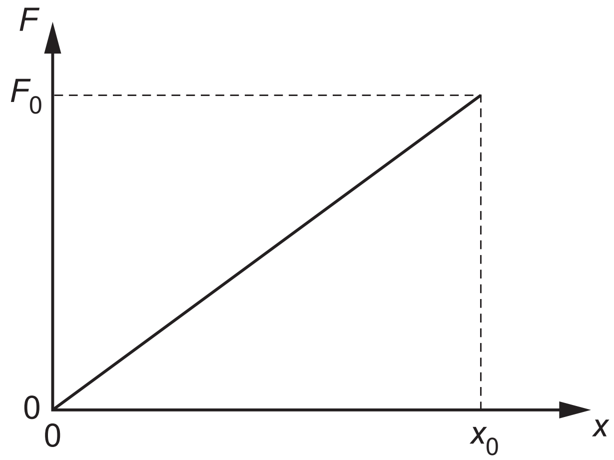


Fig. 3.2

Use the information in **(b)** and your answer in **(c)** to show that the maximum force F_0 exerted on the spring by the block is 700 N.

[2]

(e) Use the information in **(d)** to determine, for the instant that the block is first brought to rest by the spring, the magnitude of:

(i) the resultant force acting on the block

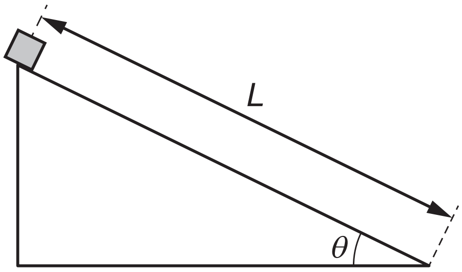
resultant force = ... N [2]

(ii) the acceleration of the block.

acceleration = ... $m\,s^{-2}$ [2]

[Total: 11]

15 A block is released from rest at the top of a slope inclined at an angle to the horizontal. The slope has length *L* as shown in the diagram.



There are no resistive forces acting on the block.

What is the speed of the block at the bottom of the slope?

A $4.43\sqrt{L\cos\theta}$ **B** $4.43\sqrt{L\sin\theta}$ **C** $19.6L\cos\theta$ **D** $19.6L\sin\theta$