Chapter 6 – Energy, Work and Power

Subject content

Content
- Energy conversion and conservation
- Work
- Power

Learning outcomes
(a) show understanding that kinetic energy, potential energy (chemical, gravitational, elastic), light energy, thermal energy, electrical energy and nuclear energy are examples of different forms of energy
(b) state the principle of the conservation of energy and apply the principle to new situations or to solve related problems
(c) calculate the efficiency of energy conversion using the formula efficiency = energy converted to useful output / total energy input
(d) state that kinetic energy E_k = ½ mv^2 and gravitational potential energy E_p = mgh (for potential energy changes near the Earth's surface)
(e) apply the relationships for kinetic energy and potential energy to new situations or to solve related problems
(f) recall and apply the relationship work done = force × distance moved in the direction of the force to new situations or to solve related problems
(g) recall and apply the relationship power = work done / time taken to new situations or to solve related problems

Definitions

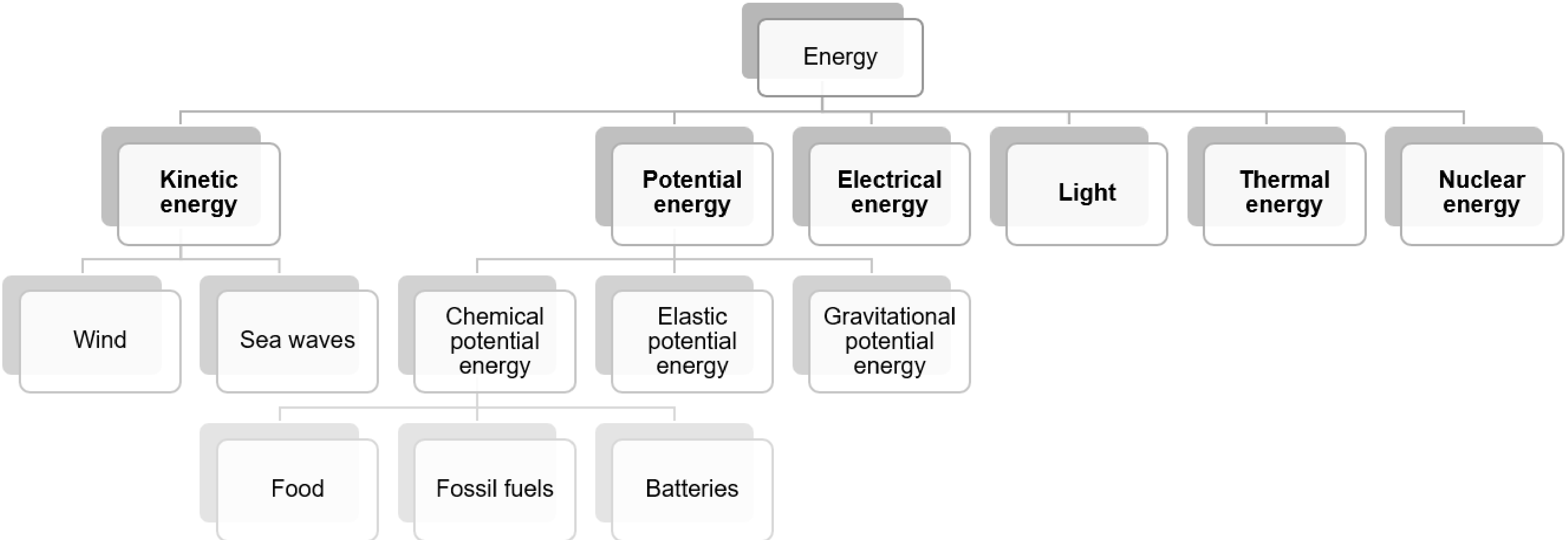
Term	Definition	SI unit
Energy	Capacity to do work	joule (J)
Principle of Conservation of Energy	Energy cannot be created or destroyed but can be converted from one form to another. The total energy in an isolated system is constant.	
Efficiency	Percentage of input energy converted into useful energy	%
Work done	Product of the force and the distance moved by the object in the direction of the force	joule (J)
Power	Rate of work done / energy conversion	watt (W)

Formulae

Principle of Conservation of Energy	Efficiency	Work
Σ initial energy + work done = Σ final energy + energy loss	Efficiency = $\frac{useful\ energy\ output}{total\ energy\ output} \times 100\%$	$W = F \times s$
Kinetic energy	**Gravitational potential energy**	**Power**
$E_k = \frac{1}{2}mv^2$	$E_p = mgh$	$P = \frac{W}{t} = \frac{E}{t}$

6.1 Energy

What is energy



Different types of energy:

<table>
<tr><th>Energy</th><th>Explanation</th></tr>
<tr><td>1. Kinetic energy</td><td>Energy of body due to motion
examples
wind
sea waves
spinning Frisbee
rolling soccer ball
turn turbines
kinetic energy → electrical energy</td></tr>
<tr><td>2. Potential energy</td><td>Energy stored in system due to state / shape / position
<table>
<tr><th>Type</th><th>Explanation</th></tr>
<tr><td>Chemical potential energy</td><td>Energy stored in body due to position of atoms / electrons
<u>Food</u>
light energy from Sun (photosynthesis)
consume plants: chemical potential energy → other energy
<u>Fossil fuels</u>
power stations
oil & gas → generate electricity
<u>Batteries</u>
connected to electric circuit
converted to electrical energy</td></tr>
<tr><td>Elastic potential energy</td><td>Energy stored in body due to elastic deformation
<u>Spring, rubber band</u>: compressed / stretched
Converted to kinetic energy when released</td></tr>
<tr><td>Gravitational potential energy</td><td>Energy stored in body due to height from ground
Raised to height above ground
Object released → kinetic energy</td></tr>
</table></td></tr>
<tr><td>3. Electrical energy</td><td>Energy of electric charge due to motion & position</td></tr>
<tr><td>4. Light</td><td>Electromagnetic wave visible to the eye
made up of electric + magnetic fields oscillating at certain range of frequency within electromagnetic spectrum
sources
<table>
<tr><th>natural</th><th>artificial</th></tr>
<tr><td>Sun
fires</td><td>incandescent bulbs
fluorescent lamps
light-emitting diodes (LED)</td></tr>
</table></td></tr>
</table>

5. **Thermal energy**	Energy stored in body due to temperature ● particles of hotter body: more thermal energy ● transferred from hotter body → colder body
6. **Nuclear energy**	Energy released during nuclear reaction ● **nuclear fission**: heavy nucleus split up → light nuclei ● **nuclear fusion**: light nuclei fuse together → heavy nucleus

Principle of Conservation of Energy

Principle of Conservation of Energy:

Σ initial energy + work done = Σ final energy + energy loss

Examples

Example	Energy conversion
1. Hammering nail	gravitational potential energy → kinetic energy kinetic energy→ sound energy + thermal energy
2. Burn fossil fuels	chemical potential energy → thermal energy + light energy

Pendulum

Ideal pendulum	Non-ideal pendulum
gravitational potential energy → kinetic energy	gravitational potential energy → kinetic energy + thermal energy

Efficiency

Total energy input = useful energy output + wasted energy output

Efficiency = $\frac{useful\ energy\ output}{total\ energy\ output}$ **× 100%**	**Efficiency =** $\frac{output\ energy}{input\ energy}$ **× 100%**

6.2 Work

Work done

Work done → energy supplied to system

$$W = F \times s$$

where W = work done by force (in J)
F = force applied (in N)

s = distance moved in direction of force (in m)

Direction of movement

Direction	Work done
force applied	✔
⊥ force applied	✖

Gravitational potential energy & kinetic energy: collectively known → **mechanical energy**

Kinetic energy

Kinetic energy

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

where m = mass of object
v = velocity of object

Gravitational potential energy

Gravitational potential energy

$$E_p = mgh$$

where m = mass of object
g = gravitational field strength
h = height to which object is raised

System	Energy
Purely mechanical (moving body)	energy change ● gain in GPE → loss in KE ● loss in GPE → gain in KE
Dissipative forces exist (friction, air resistance)	energy lost from system

6.3 Power

What is power

Power

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

where P = power (in W)
W = amount of work done (J)
t = time taken for work done (in s)

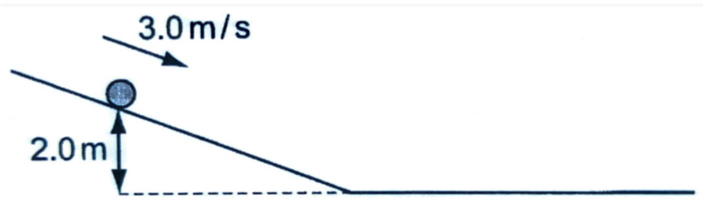
Typical questions

Multiple choice questions

1. A car moves from rest with uniform acceleration along a horizontal road.
   After travelling a distance of 100 metres, it has kinetic energy equal to 200000 J.
   What resultant force is acting on the car? (2011 P1 Q12)
   A 100 N
   B 1000 N
   C 2000 N
   D 20000 N

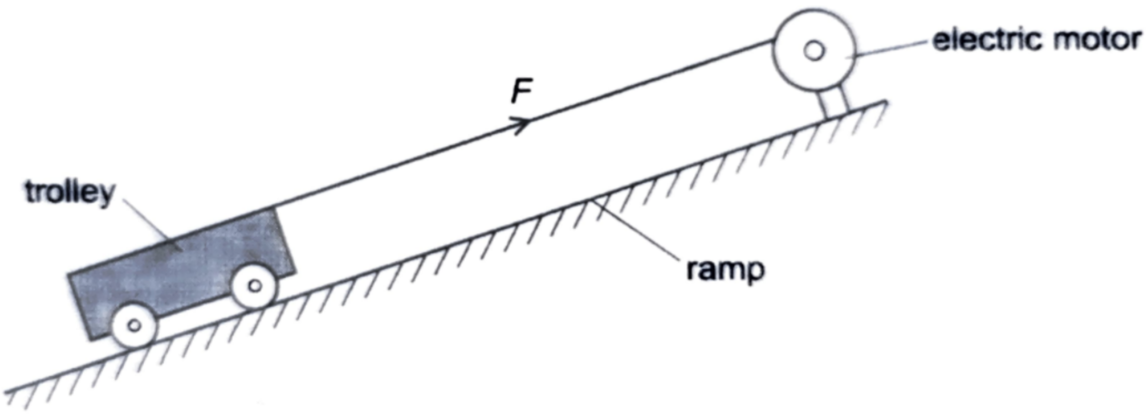
2. An experiment is carried out to estimate the useful power output of a student running up some stairs, ignoring the work done against friction. (2011 P1 Q13)
   What is not required for this experiment?
   A the time taken to run up the stairs
   B the total horizontal distance of the stairs
   C the total vertical height of the stairs
   D the weight of the student

3. A ball of mass 0.40 kg rolls down a hill.
   2.1 m above the bottom of the hill, the speed of the ball is 3.0 m/s.



   The gravitational field strength g is 10 N/kg.
   Ignoring the effects of friction and air resistance, what is the kinetic energy of the ball at the bottom of the hill? (2012 P1 Q13)
   A 1.8 J
   B 8.0 J
   C 8.6 J
   D 9.8 J

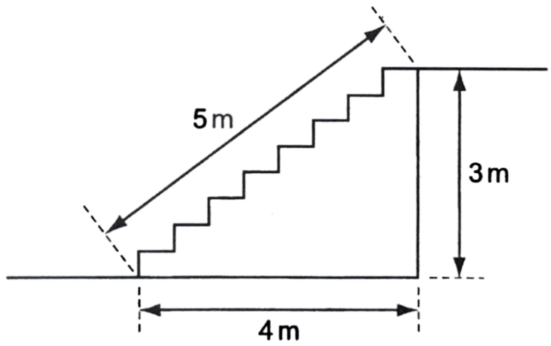
4 An electric motor produces a force *F* to pull a trolley up a ramp. There is no friction or air resistance acting.



Which quantity is equal to the work done by the force *F*? (2013 P1 Q15)

A the acceleration of the trolley
B the energy given to the trolley
C the power of the motor
D the weight of the trolley

5 The diagram shows a flight of stairs.



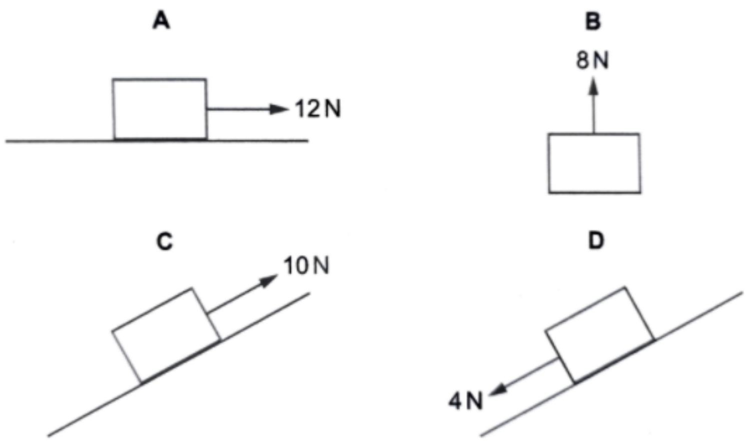
How much useful work is done by a person weighing 600 N when climbing the stairs? (2013 P1 Q16)

A 120 J
B 1800 J
C 2400 J
D 3000 J

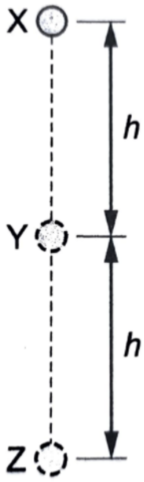
6 An electric kettle is rated at 2.5 kW.
How much energy is transferred in 3.0 minutes? (2013 P1 Q18)

A 7.5 J
B 450 J
C 7500 J
D 450000 J

7 A load is pulled by a rope attached to a motor. The resultant force exerted by the rope on the load is shown in the diagrams.
In each diagram, the load moves in the direction of the resultant force and takes 10 s to travel 1.0 m. In which diagram does the motor work with the greatest power? (2016 P1 Q12)



8 A ball is at rest at point X in a vacuum. The ball falls under gravity from X to Y to Z. Distances are shown on the diagram.



What is the ratio $\frac{kinetic\ energy\ of\ ball\ at\ Z}{kinetic\ energy\ of\ ball\ at\ Y}$? (2016 P1 Q13)

A $\sqrt{2}$
B 2
C $2\sqrt{2}$
D 4

9 Which type of energy is not a form of potential energy? (2017 P1 Q10)

A chemical
B elastic
C gravitational
D thermal

10 A lorry of a total mass of 15000 kg takes sand to the top of a hill 50 m high, unloads all of the sand and then returns to the bottom of the hill. The empty lorry has a mass of 10000 kg.
The gravitational field strength g is 10 N/kg.
What is the difference between the final gravitational potential energy and the initial gravitational potential energy of the sand? (2017 P1 Q11)

A 250000 J
B 750000 J
C 2500000 J
D 7500000 J

11 A stone enters a deep pool at high speed. It slows down as it moves towards the bottom of the pool.
What is the energy transformation as the stone moves downwards through the water?
(2018 P1 Q15)

A gravitational potential energy → kinetic energy + thermal energy (heat)
B gravitational potential energy → kinetic energy → thermal energy (heat)
C kinetic energy + gravitational potential energy → thermal energy (heat)
D kinetic energy → gravitational potential energy + thermal energy (heat)

12 Electric cars use electric motors instead of combustion engines. The electric motor can be used as a generator to charge the car's battery.
What are the energy conversions involved in this process? (2019 P1 Q13)

A thermal → kinetic → electrical
B thermal → electrical → chemical
C kinetic → thermal → electrical
D kinetic → electrical → chemical

13 An object is initially at rest. The object is dropped from a 50 m high tower.
Air resistance can be ignored. Assume that the potential energy of the object is zero when it is on the ground.
What is the ratio of the kinetic energy of the object to its potential energy at a height of 10 m from the ground? (2019 P1 Q14)

A 5 : 4
B 2 : 1
C 4 : 1
D 5 : 1

14 A lorry is travelling at a steady speed along an expressway.
The forward force is 3600 N and the power produced is 90000 J / s.
How far does the lorry travel in one minute? (2019 P1 Q15)

A 1.5 m
B 1500 m
C 90 km
D 5400 km

Structured questions

1 A car with 20 kJ of energy initially travels up an inclined road. Its engine supplies an additional 10 kJ for a short while. Assuming there is no loss of energy to the surroundings, calculate the final amount of energy possessed by the car, using the Principle of Conservation of Energy. [2]

Using Principle of Conservation of Energy,
Σ initial energy + work done = Σ final energy + energy lost
20 kJ + 10 kJ = final energy + 0 kJ
final energy = 30 kJ

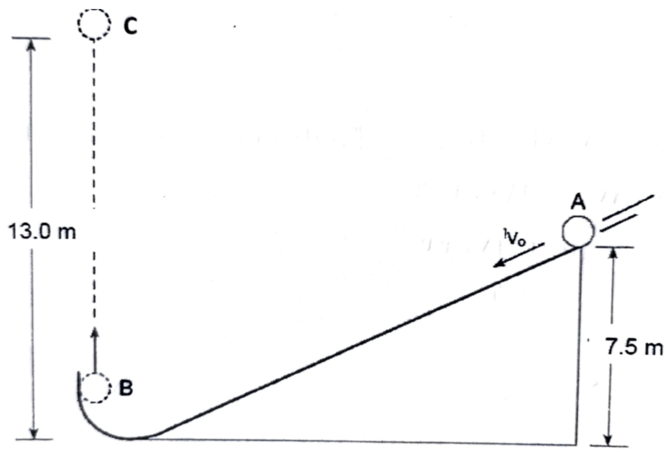
2 A 100 kg roller coaster car is at rest near the top of a 20 m high track. It is released and travels to the bottom of the track. Determine the kinetic energy of the car at the bottom of the track. Assume that the energy loss due to friction between the wheels of the car and the track is 100 J and g to be 10 N kg^{-1}. [2]

Using the Principle of Conservation of Energy,
initial E_k + initial E_p + work done = final E_k + final E_p + energy loss
0 + mgh + 0 = final E_k + 0 + 100
(100)(10)(20) = final E_k + 100
final E_k = 19900 J

3 A stationary car with a mass of 1.0×10^3 kg accelerates on a smooth horizontal road with a power output of 38kW for 10 seconds. Determine the velocity of the car at the end of 10 seconds. [2]

W = P × t = 38000 × 10 = 380000 J
initial Ep + initial Ek + work done = final Ep + final Ek + energy loss
$0 + 0 + 380000 = 0 + \frac{1}{2} \times 1000 \times v^2 + 0$
v = 27.6 m/s (3 s.f.)

4 The figure below shows a 0.80 kg ball rolling down a track from position A, which is 7.5 m above the ground. There is a frictional force along the track and this produces 10.7 J of thermal energy. The ball leaves the incline at position B, travelling straight upward and reaches a height of 13.0 m above the floor at C before falling back down.



(a) Calculate the gravitational potential energy of the ball at the highest position. [1]

$E_p = mgh$
$= (0.80)(10)(13.0)$
$= 104$ J

(b) Determine the initial velocity of the ball at position A. [2]

By Law of Conservation of Energy,
initial energy at A + work done = final energy at C + energy loss
$mgh_A + \frac{1}{2} mv^2 + 0 = 104 + 10.7$
$0.80 \times 10 \times 7.5 + \frac{1}{2} \times 0.80 \times v^2 = 114.7$
$0.40\, v^2 = 54.7$
$v = 11.7$ m/s (3 s.f.)

5 A 0.5 kg ball is thrown vertically downwards from a height of 10 m with a velocity of 5.0 m s^{-1}. It hits the ground and bounces. It then rises to a maximum height of 8.0 m. Determine the energy loss at the bounce. Assume no energy is lost due to air resistance. [2]

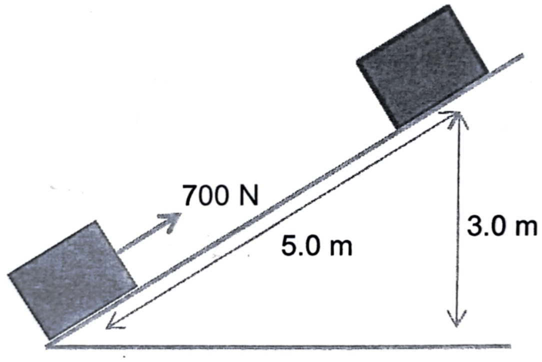
By Law of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial Ep + initial Ek + 0 = final Ep + final Ek + energy loss
$(0.5)(10)(10) + \frac{1}{2}(0.5)(5^2) = (0.5)(10)(8.0) + 0 +$ energy loss
energy loss = 16.25 J = 16.3 J (3 s.f.)

6 A 100 kg hammer of a pile-driver is lifted 20 m above the pile. It is then dropped so as to drive a pile into the ground. Suppose 15000 J of energy is lost due to friction and the resistive force of the ground is 4000 N, determine the depth of the hammer that can be driven into the soil. [2]

By Law of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial E_p + initial E_k + 0 = final E_p + final E_k + 15000
$(100)(10)(20) + 0 + 0 = 0 +$ final $E_k + 15000$
final $E_k = 5000$ J

$E_k = F \times s$
$5000 = 4000 \times s$
$s = 1.25$ m

7 The diagram shows a crate of mass 55 kg pulled up a wooden ramp by a force of 700 N at a constant speed. The crate is raised to a vertical height of 3.0 m in the process.
(Take g = 10 N/kg)



What is the frictional force on the crate along the wooden ramp? [2]

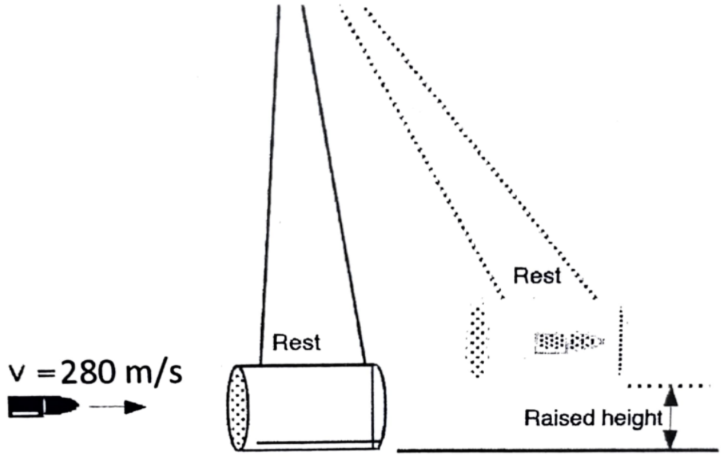
By Principle of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial Ep + initial Ek + (700)(5.0) = (55)(10)(3.0) + work against friction
0 + 0 + 3500 = 1650 + work against friction
work against friction = 1850 J

$F_f \times s = 1850$
$F_f \times 5.0 = 1850$
$F_f = 370$ N

8 The engine of a 1400 kg car does 20000 J of work when the car accelerates across a distance of 200 m in the same direction. The car was already travelling at 20 m/s before accelerating. What is the final speed of the car? [2]

By Law of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial E_p + initial E_k + work done = final E_p + final E_k + energy loss
$0 + ½ (1400)(20^2) + 20000 = 0 + ½ (1400)(v^2) + 0$
$700 v^2 = 300000$
v = 20.7 m/s (3 s.f.)

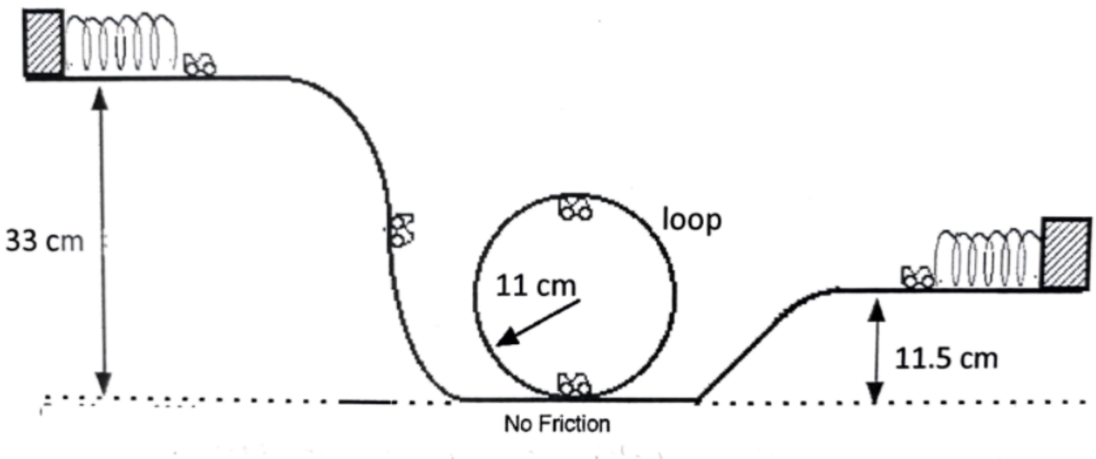
9 A speeding bullet with a mass of 0.015 kg is shot into a container of clay as shown in the figure below. The speed of the bullet just before impact is 280 m/s. The bullet was lodged inside the clay and caused the container to swing upwards (like a pendulum). The container of clay has a mass of 20 kg.



Calculate the maximum height that the container rises as a result of the impact. (Assume no energy is lost due to friction while the bullet is lodged inside the clay) [2]

By Law of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial E_p + initial E_k + work done = final E_p + final E_k + energy loss
$0 + ½ (0.015)(280^2) + 0 = (20.015)(10)(h) + 0 + 0$
h = 2.94 m (3 s.f.)

10 The figure below shows a 0.1 kg toy car moving through the tracks from an elevated position on the left. The toy car is given an initial velocity of 0.20 m/s when it is launched from the compressed spring. Assume no energy is lost due to resistive forces, determine the speed of the car



(a) when it is at the start of the loop (i.e. at the bottom of the loop) [2]

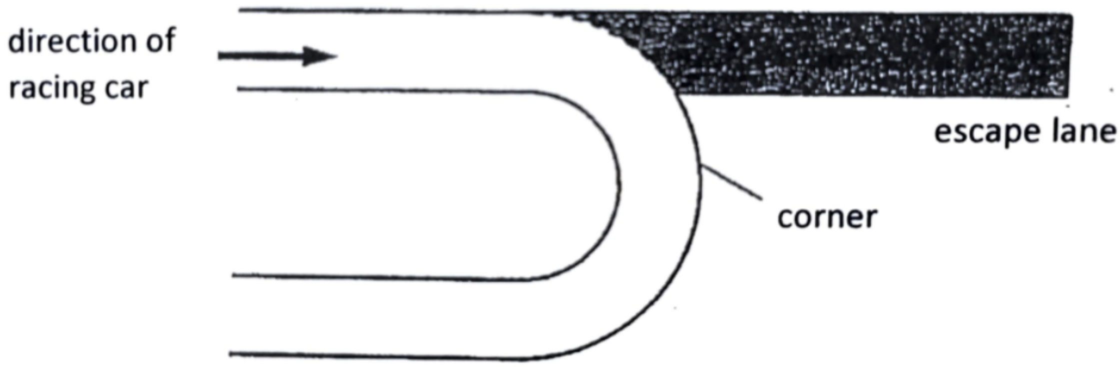
By Law of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial E_p + initial E_k + work done = final E_p + final E_k + energy loss
$(0.1)(10)(0.33) + ½ (0.1)(0.2^2) + 0 = 0 + ½ (0.1)(v^2) + 0$
$v^2 = 6.64$
v = 2.58 m/s (3 s.f.)

(b) when it is at the top of the loop [2]

By Law of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial E_p + initial E_k + work done = final E_p + final E_k + energy loss
$0 + ½ (0.1)(6.64) + 0 = (0.1)(10)(0.22)$ + final E_k + 0
final E_k = 0.112 J

$0.112 = ½ (0.1)(v^2)$
$v^2 = 2.24$
v = 1.50 m/s (3 s.f.)

11 At a sharp corner on a car racing lane, there is an escape lane as shown in the figure below.



The escape lane is a bed of small stones. The escape lane slopes upwards. A car of mass 700 kg approaches at a speed of 40 m/s. The brakes fail and the car stops in the escape lane.

(a) Describe what happens to the kinetic energy of the car as it stops. [1]

Kinetic energy → thermal energy + sound energy + gravitational potential energy

(b) The car comes to rest 40 m along the escape lane, having risen through a vertical distance of 3.0 m. The acceleration of free fall is 10 m/s^2. Calculate

(i) the change in gravitational potential energy of the car [1]

E_p = mgh
= (700)(10)(3.0)
= 21000 J

(ii) the average frictional force on the car in the escape lane [2]

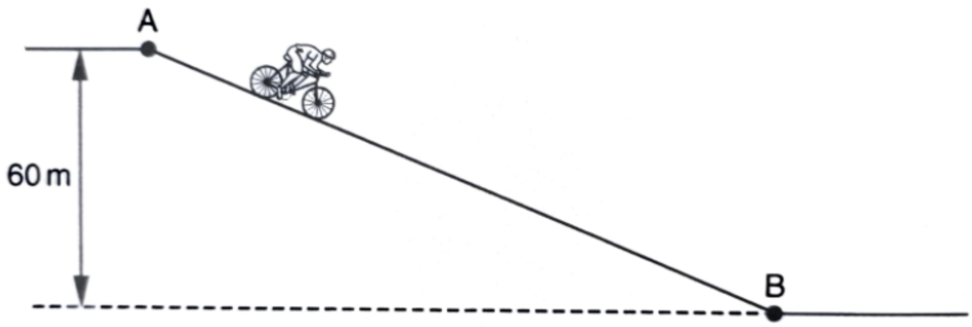
By Principle of Conservation of Energy,
initial energy + work done = final energy + energy loss
initial E_p + initial E_k + work done = final E_p + final E_k + energy loss
0 + ½ (700)(40^2) + 0 = 21000 + 0 + work against friction
work against friction = 539000

F_f × 40 = 539000
F_f = 14000 N (3 s.f.)

(c) The frictional force on the car in the escape lane is not constant. Suggest one factor, apart from the car's speed, that affects the value of the frictional force. [1]

- Texture (size of small stones) of the escape lane
- Weight of the car

12 The figure below shows a cyclist travelling down a long hill.



The cyclist starts from rest at A and rolls down the hill to B, through a vertical distance of 60 m. He does not brake or use the pedals.
The speed of the cyclist at B is 12 m/s. The total mass of the cyclist and bicycle is 90 kg. The acceleration of free fall *g* is 10 m/s^2. (2011 P2A Q2)

(a) State the principle of conservation of energy. [2]

It states that energy cannot be created or destroyed. The energy can only be converted from one form to another. The total amount of energy in an isolated system remains constant.

(b) Calculate

(i) the loss in gravitational potential energy E_p between A and B. [2]

GPE_{loss} = mgh = (90)(10)(60) = 54000 J

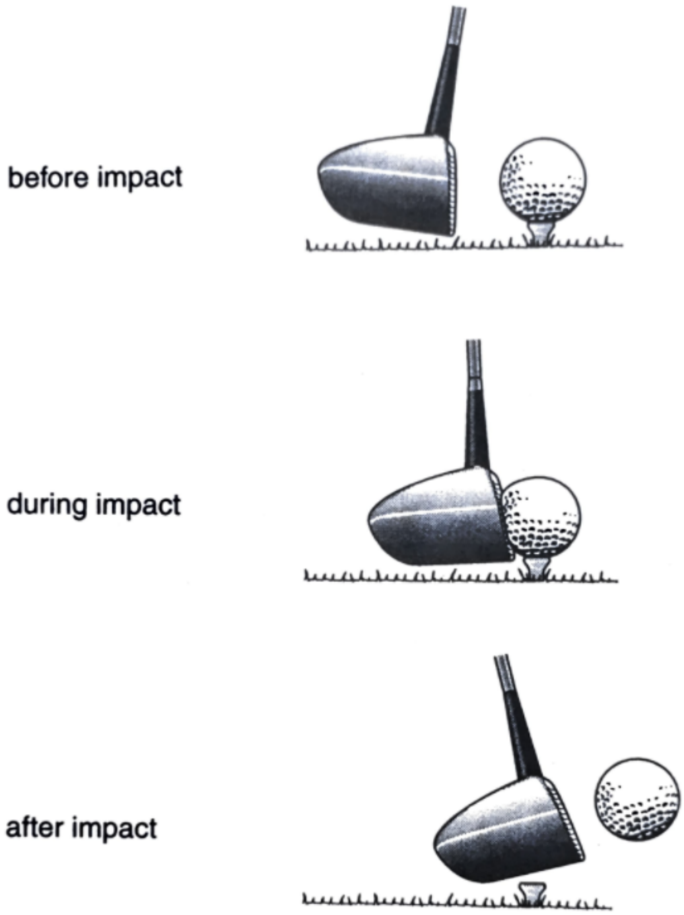
(ii) the increase in kinetic energy Ek as the cyclist travels from A to B. [2]

$KE_{increase} = \frac{1}{2} mv^2 = \frac{1}{2} (90)(12)^2 = 6480$ J

(c) Suggest why the loss in gravitational potential energy and the increase in kinetic energy are different and explain how the law of conservation of energy applies to this situation. [2]

This suggests that not all initial GPE is converted to KE. Some of the energy may be converted to thermal energy as a result of friction between the tyres and the road, as well as air resistance against the cyclists. If we were to consider all of these energy conversions, the total amount of energy converted should be equal to the initial GPE, by the Law of Conservation of Energy.

13 A golf club hits a stationary golf ball. The figure below shows three stages in the process. (2013 P2A Q3)



(a) Explain how the principle of conservation of energy applies during the impact. [3]

During the impact, most of the kinetic energy from the golf club is transferred to the golf ball, causing it to fly off. Some of the energy from the golf club is also converted to other forms of energy, such as sound and thermal energy. However, if we consider the total energy before and after the impact, they remain the same (principle of conservation of energy).

(b) The golf ball rises from the ground at A to a vertical height of 16 m at B, as shown in the figure below.
The mass of the ball is 0.045 kg. The gravitational field strength g is 10 N/kg.

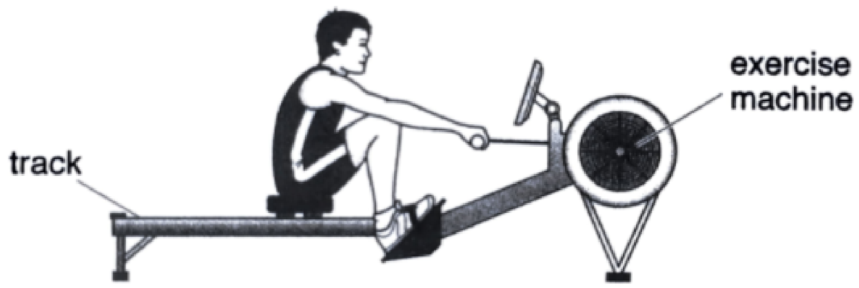
(i) Calculate the increase in gravitational potential energy of the ball between A and B. [2]

$E_p = mgh$
$= (0.045)(10)(16)$
$= 7.2$ J

(ii) At B, the kinetic energy of the ball is 2.5 J. Air resistance is negligible as the ball travels from A to B.
Calculate the kinetic energy of the ball at A. [1]

Total energy at B = 7.2 + 2.5 = 9.7 J
= Total energy at A
At A, the ball only possesses kinetic energy.
Therefore, the kinetic energy at A is 9.7 J.

14 An athlete uses an exercise machine, as shown in the figure above.



The athlete moves backwards and forwards along the track. As he pulls the handle, he moves backwards and the machine displays the force exerted by the athlete. At the end of the track, he stops pulling and then returns to the position shown. (2015 P2A Q1)

(a) An accurate value for the average time for one complete movement is obtained. Describe what measurements are taken and how they are used to find the average time for one complete movement. [3]

- A stopwatch is needed to find the time taken.
- The athlete is allowed to start exercising and when he reaches a steady state, the stopwatch starts timing when he is in the forward position as shown in the picture.
- The timing will be taken for 20 complete movements of the athlete. This is recorded as t_1.
- The average time for 20 complete movements is taken. This is calculated by $t_{avg} = (t_1 + t_2)/2$
- The average time for 1 complete movement is then calculated by taking t_{avg} / 20.

(b) A student calculates the average power input to the machine by the athlete.

(i) Apart from the measurement in (a) and the average force exerted, state the other measurement that is needed. [1]

The distance moved by the athlete along the track needs to be measured.

(ii) State, in words, the equations needed to calculate the power of the athlete. [2]

To calculate power, we need to find the work done first. This is calculated by taking the product of force exerted and distance moved by the athlete. To calculate the power of the athlete, the work done is then divided by the average time for one complete movement.

15 The highest jump to Earth was made by a sky-diver from the edge of space, as shown in the figure below. The diver was in free-fall until he opened his parachute.

The jump started from a height of 39 km above the Earth's surface and the parachute opened at a height of 3.0 km. During the free-fall, the gravitational field strength increased from 9.7 N/kg to 9.8 N/kg. The mass of the diver was 80 kg. (2015 P2A Q4)

(a) Estimate the loss in gravitational potential energy of the diver during the free-fall. [2]

Initial E_p at height of 36 km
= mgh
= (80)(9.7)(36000)
= 27936000 J

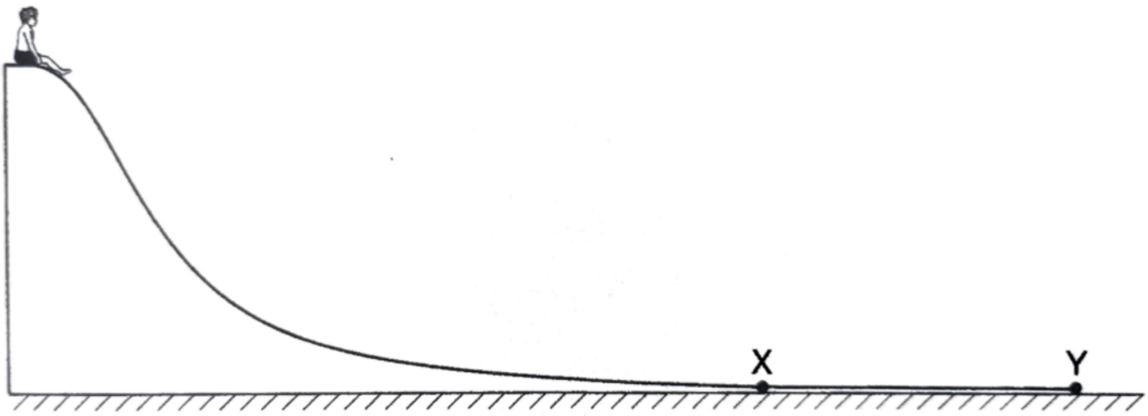
Final E_p at height of 3.0 km (end of free-fall)
= mgh
= (80)(9.8)(3000)
= 2352000 J

Loss in gravitational potential energy
= 27 936 000 – 2 352 000
= 25 584 000
= 2.56×10^7 J (3 s.f.)

(b) The effects of air resistance are very small at the start of the jump.
If air resistance is neglected, state the energy change that occurs during the fall and explain, using ideas about energy, why the speed of the diver does not depend on his mass. [2]

During the fall, there is a loss in gravitational potential energy which is then converted to kinetic energy. An object with a greater mass would have a greater amount of gravitational potential energy, but it would also require more conversion to kinetic energy to move at the same speed as a smaller object (terminal velocity). The speed of the diver thus depends on the gravitational field strength, rather than the mass of the diver.

16 The figure below shows a child at the top of a slide.



An accurate value for the average time for one complete movement is obtained.
The child has a mass of 60 kg and his speed at point X on the slide is 2.5 m/s.

(2018 P2A Q3)

(a) An accurate value for the average time for one complete movement is obtained.
Calculate the kinetic energy of the child at point X. [2]

KE = ½ mv^2 = ½ (60)(2.5^2) = 187.5 J

(b) The child stops at point Y on the slide. Between points X and Y, all the kinetic energy of the child becomes internal energy.

(i) Describe, in terms of the forces acting, how this conversion of energy occurs. [2]

Due to friction acting in the opposite direction on the child, the child slows down. As the child slows down, he has less kinetic energy. The decrease in kinetic energy is equivalent to the amount of energy converted to internal energy.

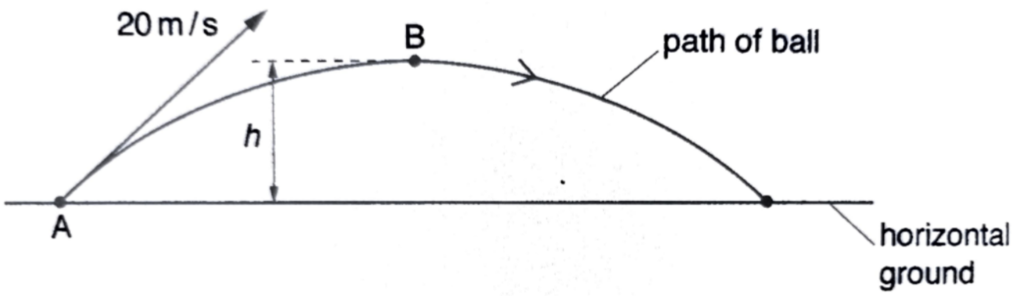
(ii) Describe what is meant by *internal energy*. [1]

Internal energy refers to the sum of the internal potential and kinetic energies.

(iii) State why there is no change in gravitational potential energy between points X and Y. [1]

The height of the child's centre of gravity above the ground remains the same.

17 The figure below shows the path of a metal ball fired into the air at an angle to the horizontal. Air resistance has a negligible effect on the motion of the ball. (2019 P2A Q3)



(a) At point A, the ball has kinetic energy. At point B, the ball has kinetic energy and gravitational potential energy.
State what is meant by kinetic energy and gravitational potential energy. [2]

Kinetic energy is the energy possessed by the object due to its motion, and given by $E_k = \frac{1}{2}mv^2$.
Gravitational potential energy is the energy stored in the object due to its height above ground, and given by $E_p = mgh$.

(b) The metal ball has a mass of 1.5 kg. The speed of the ball at A is 20 m/s.

(i) Calculate the kinetic energy of the ball at A. [2]

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(1.5)(20)^2 = 300$ J

(ii) The kinetic energy of the ball at B is 180 J. Calculate the gain in gravitational potential energy of the ball as it moves from A to B, and the change in vertical height *h* of the ball as it rises from A to B (gravitational field strength *g* = 10 N/kg) [1] [2]

Since the total energy should remain constant, assuming there is no energy dissipated or lost, the difference in kinetic energy is the amount of gain in E_p = 300 – 180 = 120 J.

h = E_p / mg = 120 / (1.5)(10) = 8 m