ANSWERS

CYCLING (2014; 1 – AS90940)

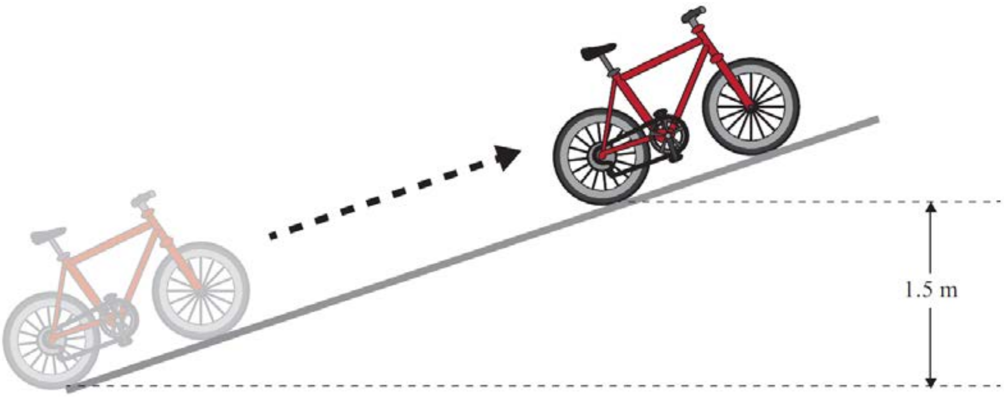
(c) A bike with a mass of 20 kg is lifted onto a shelf that is 1.5 metres high. It takes 3 seconds to lift the bike.
Calculate the power required to lift the bike onto the shelf.

Before you calculate the power, you will need to:

- determine the weight force of the bike F = 20 × 10 = 200 N
- calculate the work done in lifting the bike. W = F × d = 200 × 1.5 = 300 J

P = W / t = 300 / 3 = 100 W

(d) A person pushed the same bike up a ramp so that it was also at a height of 1.5 m. It took them a longer time to do this than lifting the bike in part (c).



Explain whether the power needed to push the bike up the ramp is more or less than when it is lifted straight up to the same height. In your answer you should refer to force and energy.

As the height above the ground is the same, **the same work is required** to travel up the ramp as lifting the bike straight up. If the same amount of work is done, the same amount of energy is gained.
As *W* = *F* × *d*, if *d* is increased, the amount of force required to do the same amount of work will be less, ie a ramp allows the same amount of work to be done with a smaller force over a greater distance.

OR

Going up the ramp, the push force required is against a component of the gravity force of the bike. A vertical lift would require a push equal to gravity force. Therefore the force required to lift the bike straight up is greater than the force required to push it up the ramp.

The energy gained by the bike is the same in both cases, but the time taken to go up the ramp is greater than lifting it vertically. As *P* = *W* / *t*, a greater time would mean less power is required.

CONSTRUCTION (2014; 3 – AS90940)

During the construction of a building, a long beam was lifted into place using a crane.

(a) Calculate the work done in lifting the beam with a weight of 6000 N through a distance of 50 m.
W = F × d = 6 000 × 50 = 300 000 J

(b) Explain why there is no work being done when the beam is hanging in the air without moving.
Work is done when a force causes the beam to move in a direction of the force. The force is not causing the object to move, so no work is being done. (No distance travelled in the direction of the force)

(c) Another crane was lifting wood. The cable broke, and 150 kg of wood fell 12 m to the ground below. The wood had 15 000 J of kinetic energy just before it landed on the ground below. This was different from the amount of energy the wood had when it was hanging from the crane.
Explain why there is a difference in the energy the wood had when it was hanging from the crane compared to just before it hit the ground.
In your answer you should:

- name the type of energy the wood had when it was hanging from the crane
- calculate how much energy the wood had when it was hanging from the crane
- calculate the difference between the kinetic energy of the wood just before hitting the ground and the energy the wood had when it was hanging from the crane
- justify the difference in energy of the wood when it was hanging from the crane and then just before it hit the ground.

Explanation of energy difference:

At the top, the wood has a certain amount of gravitational potential energy and no kinetic energy.

Just before the wood hits the ground, the gravitational potential energy has been converted into kinetic energy.

E_P calculation: $E_P = mgh = 150 \times 10 \times 12 = 18\,000$ J

Difference between E_P and E_K: = 18 000 – 15 000 = 3 000 J

Energy loss:
Some kinetic energy is lost as heat energy due to the frictional force of air resistance.

DROPPING A BALL (2013; 2 – AS90940)

In a classroom experiment, a ball is dropped onto the floor.
Before the ball is dropped, it is not moving, and has only gravitational potential energy (E_p). As the ball falls, the gravitational potential energy is converted into kinetic energy (E_k).
The ball has a mass of 100 grams.

(a) Complete the labels for the diagram below to show the energy changes as the ball is dropped. Assume that the gravitational potential energy is changed only into kinetic energy.

At the top: $E_p = 0.2$ J $E_k = 0$ J

Halfway: $E_p =$ ________ $E_k =$ ________

Just before it hits the floor: $E_p =$ ________ $E_k =$ ________

Halfway: $E_p = 0.1$ J $E_k = 0.1$ J
At the bottom: $E_p = 0$ J $E_k = 0.2$

(b) The teacher tells the students that the ball will be travelling at 2 ms^{-1} just before it hits the floor. The students are asked to predict the speed of the ball halfway down from three options:
Option 1: The speed is less than 1 ms^{-1}.
Option 2: The speed is equal to 1 ms^{-1}.
Option 3: The speed is greater than 1 ms^{-1}.

State the correct option, explain your answer, and support your answer using energy calculations. You may assume conservation of energy.

Option 3.

At halfway $E_k = 0.1$ J = ½mv^2 = ½ × 0.1 × v^2
$v^2 = 2$
v = 1.41 ms^{-1}

OR

if v = 1 m s^{-1} E_k = ½mv^2 = 0.05J
while halfway E_k = 0.1 J > 0.05J
so v >1 ms^{-1}

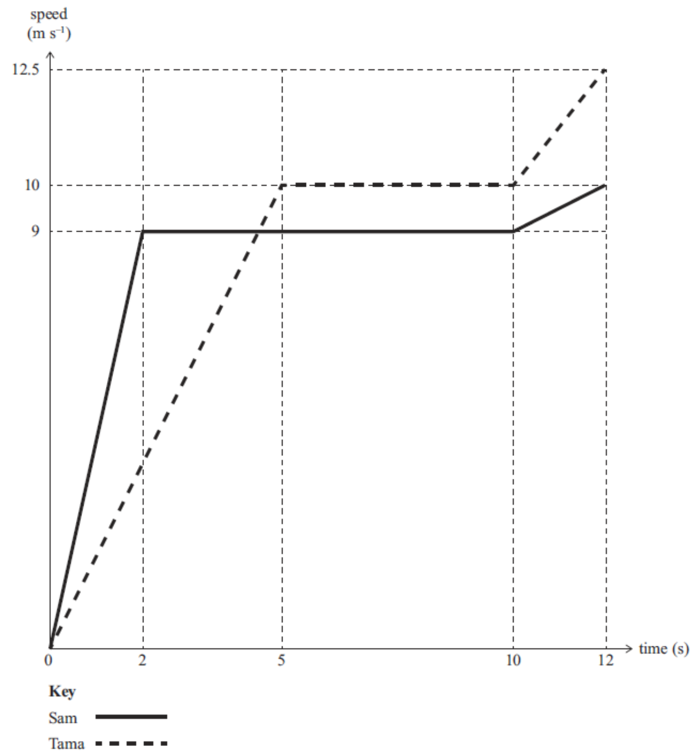
(c) Explain why the ball will really be travelling slower than 2 m s^{-1} just before it hits the floor.
No calculation is required.
In your answer you should:
- describe all the energy changes that occur as the ball falls
- explain why the energy changes mean the speed is slower than 2 m s^{-1}.

In reality there are losses for energy due to friction / air resistance. This means that some of the initial gravitational potential energy is converted into heat and sound as well as kinetic energy. As a consequence the kinetic energy is less than for an ideal case, and the ball falls slower.
Air resistance / friction occurs as the ball falls, because the ball is pushing past air particles.
As the air particles rub against the ball heat and sound are generated.

SCIENCE: 90940 DEMONSTRATE UNDERSTANDING OF ASPECTS OF MECHANICS: ENERGY

100 METRE RACE (2012;2 – AS90940)

On athletics day, two friends compete in the same 100 metre race. The speed-time graphs for 12 seconds of their race are shown here.



(b) Sam accelerates for the first 2 seconds of the race. During this time, he covers a distance of 9 m. His mass is 60 kg. Using the graph, calculate Sam's **acceleration** during the first 2 seconds, AND then calculate the **work done** to cover the distance of 9 m.

To calculate work done:

a = slope = 9/2 = 4.5 m s^{-2}

$F = ma = 60 \times 4.5 = 270$ N

$W/E = F \times d = 270 \times 9 = 2430$ J

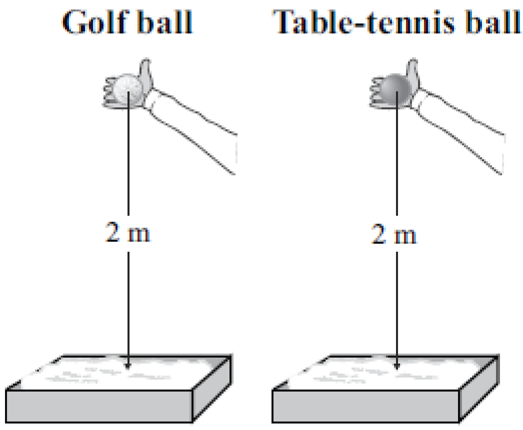
OR

$E_k = ½mv^2 = ½ \times 60 \times 9^2 = 2430$ J

CRATERS (2012;3 – AS90940)

Some students wanted to investigate how craters form. They dropped two different balls – a golf ball (m = 0.046 kg) and a table-tennis ball (m = 0.003 kg), from a height of 2 m into a container filled with flour.

(c) Assuming conservation of energy calculate the speed of the **golf ball** when it hits the flour.



Assuming conservation of energy

E_p lost = E_k gained

$mgh = ½mv^2$

$0.046 \times 10 \times 2 = ½ \times 0.046 \times v^2$

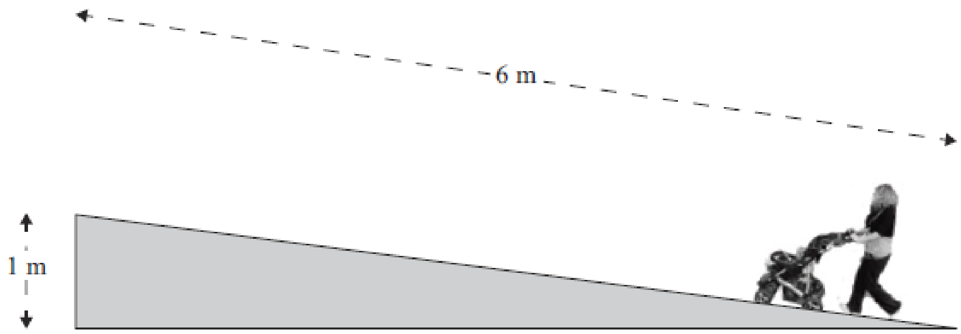
$0.92 = 0.023\ v^2$

$0.92 / 0.023 = v^2$

$40 = v^2$ $\quad v = \sqrt{40} = 6.32$ m s^{-1}

RAMPS (2012;4 – AS90940)

A woman pushes a child in a buggy up a ramp as shown below. The woman pushes the buggy up the ramp with a force of 100 N.



(a) Calculate the **work done** to push the buggy and child up the ramp.

$W = Fd = 100 \times 6 = 600$ J

(b) The energy gained by the buggy and child (m = 55 kg) at the top of the ramp does not equal the work done. Explain why these two values are not equal. In your answer you should:

- Name the type of energy the buggy has, when it reaches the top of the ramp

  Type of energy at top is gravitational potential energy

- Calculate the difference between the work done and the energy at the top of the ramp

  $E_p = mgh = 55 \times 10 \times 1 = 550$ J Energy difference = 600 – 550 = 50 J

- Explain where the "missing" energy has gone and why this occurs
  More energy is used to get up the ramp as some of the energy is being converted into heat (and sound), due to friction between the wheels and ramp, or the buggy's moving parts.

(c) Explain, in terms of force and energy, why it is **easier** to push the buggy and child up a ramp **than** to lift it straight up.

As the height above the ground is always the same, the same amount of work is required to travel up the ramp as lifting the buggy straight up. As $W = F \times d$, if d is increased, the amount of force required to do the same amount of work will be less, making it easier to push up the ramp. In other words a long ramp allows the same amount of work to be done with a smaller force over a greater distance.

Can be shown by calculation, eg, to lift straight up, force has to be greater than weight of buggy, which is $F = 55 \times 10 = 550$ N, whereas force used to push it up the ramp was only 100 N.

OR

When going up the ramp, the push force required is against a component of the gravity force of the child and buggy. A vertical lift would require a push equal to the gravity force.

The energy gained by the buggy is the same in both cases, but the time taken to go up the ramp would be much greater than lifting vertically. As $P = E / t$, a greater time would mean less power is required.

ROPE CLIMBING (2011;3 – AS90940)

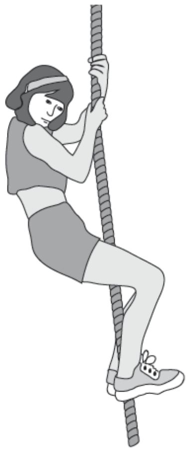
A girl of mass 60 kg uses 5 100 J of energy when she climbs a vertical rope.

(a) Calculate the maximum height it would be possible for the girl to reach.

$E_P = mg\Delta h$

$\Delta h = 5100/(60x10) = 8.5$ m

(b) In reality, the girl reaches a height of only 8 m.



Explain why the **energy** used by the girl during the climb does **not** equal the work she does to reach the vertical height of 8 m.

In your answer you should:

- name the type of energy the girl has when she is 8 m above the ground

  Gravitational potential energy.

- calculate the work done to reach a height of 8 m above the ground

  $W = Fd = 60 \times 10 \times 8 = 4\,800$ J

  OR

  $W = E_P = mg\Delta h = 60 \times 10 \times 8 = 4\,800$ J

- calculate the difference between the work done and the energy used by the girl

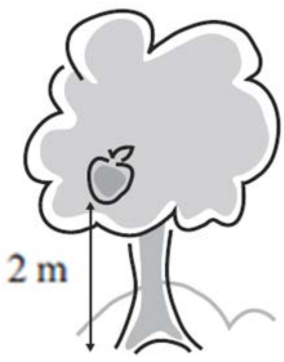
  Work done is energy gained,
  so energy difference = 5 100 – 4 800 = 300J

- explain where the "missing" energy has gone, and why this occurs
  The difference is due to energy being converted into heat in the muscles of her body.

Please note – the questions that follow are from an older Achievement Standard where the questions were more short answer-type questions:

FALLING (2010;3 – AS90191)

The diagram shows an apple (m = 0.15 kg) on a tree. The apple is 2 m above the ground.



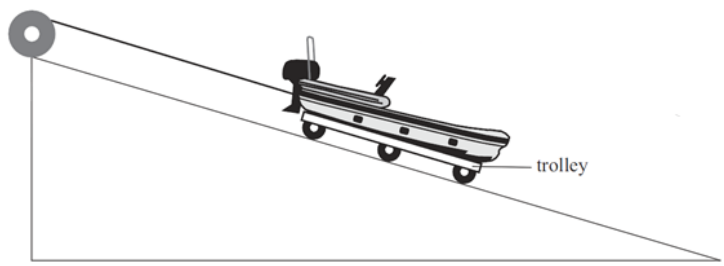
(a) Calculate the gravitational potential energy of the apple on the tree. Give an appropriate unit.

$E_p = mgh = 0.15 \times 10 \times 2 = 3$ J

RESCUE BOATS (2010;3 – AS90183)

(e) During an emergency, the rescue boat is launched using a ramp. The boat is placed on a trolley and then it is lowered down or pulled up the ramp using a cable and an electric motor.

On one occasion, the boat and the trolley are hauled up the ramp at a constant speed.



In terms of the concepts of force and energy, explain why it is easier:

(i) to haul the boat up using a **ramp**, rather than lifting it vertically up

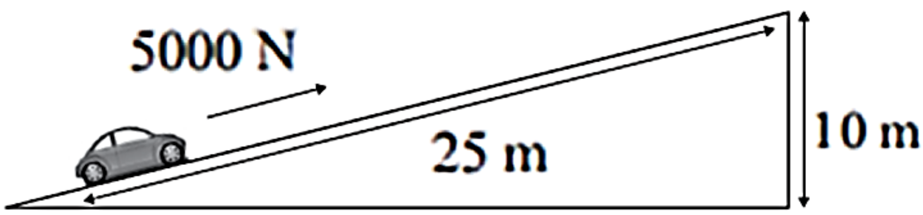
The advantage of using a ramp is that FORCE is lessened over a longer DISTANCE. ($W = F \times d$) for the same WORK.

(ii) Use a **trolley** to haul the boat up the ramp, as shown in the diagram above.

The wheels minimise FRICTION, so less ENERGY lost / less energy used so less FORCE needed

ENERGY (2009;2 – AS90191)

A car drives 25 m up a slope and stops.



(a) Calculate the work done by the car as it travels up the slope, and give the appropriate unit.

$W = F \times d = 25 \times 5000 = 125\ 000$ Joule, J

(b) The energy gained by the car (m = 1200 kg) at the top of the slope does not equal the work done. Discuss why these two values are not equal. In your answer you should:

- Name the type of energy the car has, when stopped at the top of the slope

  Gravitational Potential Energy

- Calculate the difference between the work done and the energy at the top of the slope
  $E_p = mgh = 1200 \times 10 \times 10 = 120\ 000$ J

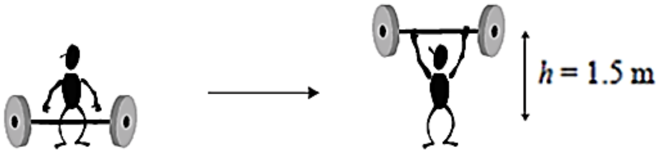
- Explain where the "missing" energy has gone and why this occurs.
  Friction occurs between the tyres and road OR Air resistance occurs with the car OR Friction occurs in the moving parts of the engine / car OR Heat is produced.

A REMOTE CONTROL CAR (2008;2 – AS90191)

(b) A child plays with a remote control car on concrete. The mass of the car is 400 grams (0.4 kg). The car then travels 28 m at a constant speed of 4 m s^{-1} for 7 seconds. Calculate the kinetic energy of the car at this speed.
$E_k = ½mv^2$
$= ½ \times 0.4 \times 4^2$
$= 3.2$ J

SPORTS TRAINING (2007;1 – AS90191)

Part of an athlete's training involves weight training. The athlete lifts a 100 kg set of weights above his head, so that the height is changed by 1.5 m.



(i) Calculate the work done by the athlete to lift the weights to the new height of 1.5m above its original position. Give an appropriate unit.
$F_g = mg$
$= 100 \times 10$
$= 1000$ N

(j) Describe the major energy change that occurs when the athlete drops the weights from the new height.
Joules / J / Nm

CYCLING (2006;1 – AS90191)

(e) The speed of Toni on her bike is 8.3 m s^{-1} and the combined mass of Toni and her bike is 70 kg. Calculate the kinetic energy of Toni and the bike as she travels at that constant speed.
$E_k = ½mv^2$
$= ½ \times 70 \times 8.3^2$
$= 2411$ J
or $= 2431$ J (if used unrounded v)

TANDEM SKYDIVING (2005;1 – AS90191)

Ariana wins a competition for a Tandem Skydive. The plane flies to a height of 5 000 m above sea level. Ariana is strapped to her jumpmaster. Ariana and the jumpmaster have a combined mass of 150 kg.

(a) Find the combined weight of Ariana and the jumpmaster.
$F_{gravity} = 150 \times 10$

= 1 500 N

(b) Calculate the amount of gravitational potential energy Ariana and the jumpmaster have just before they jump out of the plane at 5 000 m.

Ep = mgh

= 150 x 10 x 5 000

= 7 500 000 J

THE GAME CONTINUES (2004;3 – AS90191)

Jacki's team bats later in the day. When Jacki first strikes the ball, she hits it badly and it travels straight up.

(a) The ball left the bat with an initial speed of 20 ms^{-1} The mass of the ball is 160 g (0.16 kg). Find the initial kinetic energy of the ball.

$E_k = ½mv^2$

$= ½ \times 0.16 \times 20^2$

= 32 J

(b) Assuming that the energy is conserved throughout the upward flight of the ball, calculate the maximum height reached by the ball.

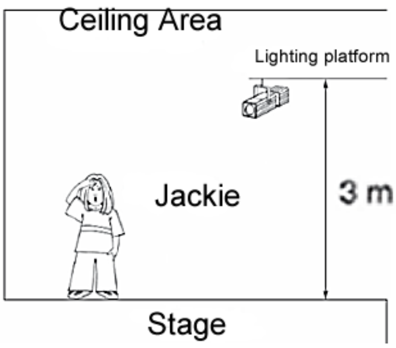
$E_k = E_p$

32 = 0.16 x 10 x h

h = 32 / (0.16 x10)

= 20 m

QUESTION ONE (2003;1 – AS90191)



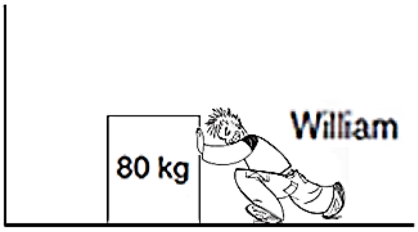
(f) A group of friends have decided to help in the school stage production. Jackie helped carry the bar and spotlights up a ladder. The bar and spotlights were fixed in place 3 m from the stage floor. Calculate the gravitational potential energy gained by the bar and spotlights. The units are required.

Ep = mgh

= 30 × 10 × 3

= **900 J**

QUESTION TWO (2003;2– AS90191)



(c) The box William is pushing is pushed at 3 m s^{-1} and has a mass of 80 kg. Calculate the box's kinetic energy. The units are required.

$E_k = ½mv^2$

$= ½ \times 80 \times (3.0)^2$

= **360 J**