6.7 Work and energy

Calculating energy

Skills: Understanding, Numeracy

Movement involves *energy*. Energy is the ability to do *work*. Work happens whenever things are shifted or rearranged by a force. The bigger the force, the more work done.

To calculate work and energy, there are three equations, as follows.

Work = force applied × distance shifted
or $W = Fs$

Kinetic energy = ½ × mass × speed × speed
or $KE = ½ mv^2$

Gravitational potential energy = mass × acceleration due to gravity × height
or $GPE = mgh$

Questions

1 **Calculate:**

a the work done by Carlie when she uses a force of 10 newtons to move her desk a distance of 5 metres across the classroom

b the energy used when she uses a force of 15 newtons to lift her school bag 1.2 metres off the ground into the bus

c the kinetic energy used by Carlie as she runs for the bus. She has to run at 5 m/s and her mass is 50 kilograms.

2 Justin is about to dive off the 5 m board. His mass is 60 kg.

a **Calculate** his gravitational potential energy before the dive.

b **Describe** what will happen to the potential energy when he dives.

c **Predict** his kinetic energy just before he enters the water.

d **Describe** where all this kinetic energy goes when he enters the water.

Calculating energy

Skills: Understanding, Numeracy

3 Rima is conducting an experiment about kinetic and potential energy. She starts by holding a 1 kilogram mass at a height of 2 metres above the floor.

a **Calculate** the amount of potential energy of the object if the acceleration due to gravity is 9.8 m/s^2.

b Rima released the mass and it fell to the floor. **Calculate** the potential and kinetic energy of the mass at different points during the fall to complete the columns of the following table.

Height above ground (m)	Potential energy (J)	Kinetic energy (J)
2.0		
1.5		
1.0		
0.5		
0.0		

c **Describe** any trend between the two energy columns.

d **Calculate** the velocity of the mass just as it hits the ground.

8.6 Work and energy

Science understanding

Logical/Mathematical

1 **Calculate** the work done in the following situations. Show your working.

(a) A weightlifter applies a force of 784 N in order to lift a heavy barbell 2.1 m above the ground.

(b) Tayla lifts a sports bag with a force of 280 N to raise it 1.3 m from the ground into the boot of her car.

2 **Calculate** the kinetic energy of the following moving objects.

(a) Diego is moving in a dodgem car at a speed of 8 m/s; the combined mass of Diego and the dodgem car is 325 kg.

(b) A seagull of mass 0.5 kg is flying at a speed of 12 m/s.

3 **Calculate** the gravitational potential energy in each of the following situations.

(a) Sophie of mass 18 kg is sitting at the top of a 20 m climbing structure made from steel cables.

(b) A paint tin of mass 200 g is resting on a 1.5 m high shelf in a garage.

4 A car of mass 12 100 kg is travelling at 15 m/s. The driver sees that the traffic light ahead has changed to red and applies the brakes, bringing the car to a stop.

(a) **Calculate** the initial and final kinetic energy of the car.

(b) **State** the change in kinetic energy as the car comes to a stop: _____ J

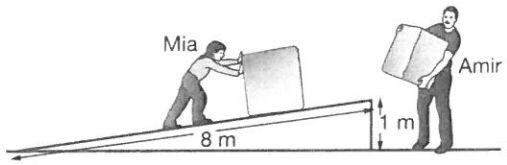
(c) The change in kinetic energy is equal to the work done by the brakes in stopping the car. **State** the work done by the brakes in stopping the car: _____ J

(d) Given that a force of 18 150 N was supplied by the brakes of the car, **calculate** the distance over which the car slowed to a stop.

_____

_____

5 Mia and Amir need to lift 5 kg packing boxes by 1 m into a truck. Amir lifts his box vertically, while Mia pushes her box up a ramp.



(a) **Calculate** the increase in gravitational potential energy of each box, assuming the acceleration due to gravity is 9.8 m/s^2.

_____

_____

(b) **State** whether Mia or Amir did more work in shifting or lifting the packing box.

_____

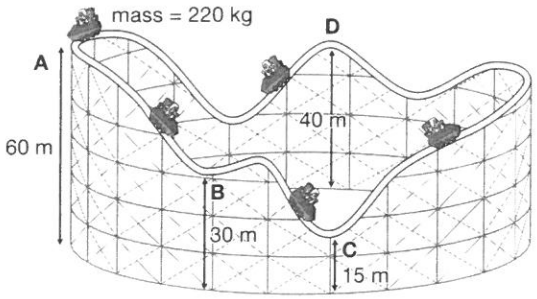
(c) **Justify** your answer to part (b).

_____

7 This diagram shows the rollercoaster that Tina and Rebecca rode on at a fun park.

(a) **Calculate** their gravitational potential energy at point A at the top of the first hill.

_____



(b) **Describe** how the gravitational and potential energy of the cart has changed as the girls ride through point B on the track.

_____

_____

(c) **Calculate** the gravitational potential energy at point C.

_____

(d) Ignoring energy losses due to friction, **calculate** the girls' speed at point C, rounding off your answer to one decimal place.

_____

_____

_____

Conservation of energy

Formulae to use

$E_p = mgh$ $E_k = \frac{1}{2}mv^2$ $F_g = mg$ $W = Fd$ $g = 10\ ms^{-2}$

1. Calculate the total energy of each of the following.

   (a) A 2 kg rock at the top of a 10 m cliff

   (b) An 80 kg bungy jumper at the top of a 35 m bungy jump

   (c) A 40 kg child running at 1.5 ms^{-1}

   (d) An 80 kg adult running at 1.5 ms^{-1}

2. Solve these problems.

   (a) A 1 000 kg car is at rest at the top of a 45 m hill. What is its gravitational potential energy?

   (b) Ignoring friction, how fast would this car be travelling if it was allowed to roll down the hill?

   (c) What is the weight force of this car?

   (d) How much work would have to be done to tow the car back up to the top of the hill?

3. A 1 kg rock is dropped from a cliff that is 20 m high. At exactly half way down, what is the total energy of the rock and what forms does the energy take?

8.7 Literacy review

Science understanding

Verbal/Linguistic

1 **Use** the clues to **identify** the words.

Clue	Word
The straight line distance between the finishing and the starting point, written with a direction	d _ _ p l _ _ _ _ _ _ _ _
A quantity that has size but not a direction	s _ _ _ _ r
A quantity that has size and direction	v _ c _ _ _
The rate of change of distance	s _ _ _ _
The rate of change of displacement	v _ _ _ _ _ _ y
The rate of change of velocity	a c _ _ _ _ _ _ _ _ _ _ _
Another name for Newton's first law	i _ _ _ _ _ a
The acceleration of an object depends upon the size of the force acting and the object's _____	m _ _ _
For every action force there is an equal and opposite _____ force.	r _ _ _ _ _ o n
When a force moves an object, this has been done.	w _ r _
The rate at which work is done	p _ _ e _
The unit used to measure work and energy	j _ _ l _
The type of energy a moving object has	k _ _ _ _ _ c
The energy of an object due to its position is potential energy.	g _ _ _ _ _ _ _ _ _ _ _ a l
The energy of a stretched or compressed spring is _____ potential energy.	e _ _ _ _ i _
A measure of the amount of useful energy produced	e _ _ _ _ _ _ _ _ y

2 **Summarise** the key equations used in forces and energy.

	Symbol	Formula
Average speed	v	
Average acceleration	a	
Newton's second law	F_{net}	
Work done	W	
Power	P	
Kinetic energy	E_k	
Gravitational potential energy	E_p	
Efficiency	Efficiency	

6.8 Crossword

Chapter review

Skills: Knowledge, Literacy

Across clues

4 $F = ma$ is Newton's _____ Law (6)
6 Moving energy (7)
10 Potential energy due to height (13)
11 Unit for mass (8)
16 Rate of change in velocity (12)
17 Squashed (10) ✓
19 Potential energy in a rubber band (7)
21 Type of timer with electric hammer used to measure motion (6)
23 Acceleration towards a planet is due to this (7)
24 Velocity achieved when weight and air resistance are balanced (8)
25 The law of inertia is Newton's _____ Law (5)
27 The effect of no force being applied (7)
28 Deceleration (11) ✓
29 When forces cancel (7)
30 Needed to do work (6)

Down clues

1 Resistance force that reduces rate of fall (3)
2 Weapons do this (6) ✓
3 Effect noticeable in a falling lift (14) ✓
5 Unit for force (6)
7 For every action, there is an equal and opposite _____ (8)
8 Distance and direction from the start (12)
9 Amount of matter (4)
12 Slope of a graph (8)
13 Speed with direction (8)
14 Reaction distance + braking distance = _____ distance (8)
15 Negative acceleration (12)
18 At rest (10)
20 Needed to apply a force (4)
22 The spring _____ measures the stiffness of an elastic material (8)
25 Push or pull (5)
26 $\frac{\text{Distance}}{\text{Time}}$ equals average _____ (5)

Head start ✓ These clues have been completed for you.

Chapter review

Skills: Knowledge, Literacy