Science Module 3

Force and Motion

Answer sheets

Curriculum Project

Chapter 1: Motion

A. Understanding motion

ANSWERS TO EXERCISES:

(i) a. no **b.** no **c.** yes **d.** no

(ii) a. You can find some way to measure it over a longer time.
b. We are spinning at the same speed and in the same direction as the Earth's surface under our feet.
c. Suggestions: the planets and their moons

Distance and displacement

ANSWERS TO EXERCISES:

(i) The displacement of both women is 50 m – it is the same, but the woman who moved in a curved line has travelled a greater distance. – Of course! – The shortest distance between 2 points is always a straight line.

(ii) a. Person 2 has travelled the greatest distance.
b. Person 1 has the greatest displacement.
c. Person 2 has travelled the greatest distance (30 m), persons 1 and 3 have travelled the same distance (20 m).
d. Person 1 has the greatest displacement (20 m), person 2 has the next greatest displacement (10 m), and person 3 has the least displacement (0 m).

(iii) No. The girls displacement = 0. The distance she has travelled is 2 x the distance from her house to the shop.

(iv) The person who gives up half-way has the greatest displacement. The person who completes the race has a displacement of 0.

B. Vector and scalar quantities

ANSWERS TO EXERCISES:

(i) v **(ii)** s **(iii)** v **(iv)** s **(v)** s **(vi)** s **(vii)** v **(viii)** s **(ix)** s **(x)** s **(xi)** s **(xii)** v

C. Speed

Speed is a **rate**: distance divided by time.

The fastest person goes the greatest distance in the same time **or** goes the same distance in less time.
Easy example:

A fast car is travelling at 90 km/hr, and a slower car is travelling at 45 km/hr. How long will it take each car to travel 90 km? How long would it take a faster car which was travelling at 120 km/hr?

D. Velocity

ANSWERS TO EXERCISES:

(i) 50 +70 = 120 m apart.

(ii) This question is wrongly worded and not well thought out.
Change this question to: Two cars are travelling towards each other on the same straight road. One car goes through village A and the other goes through village B. Villages A and B are 2,000m apart, and the cars go through the villages at the same time, both travelling at 25 m/s. How many seconds after passing through the towns will it take the cars to meet?
Answer: The cars are moving towards each other at 50 m/s. 2,000 divided by 50 = 40. The cars will meet 40 seconds after they go through the villages.

Extra question. The speed of cars is usually measured in km/hr. What is 25 m/s written as km/hr?

(iii) This question is badly worded. The question should say that both cars start from a known position.
Answer: As we know only the speed of the first car, but not its direction, we cannot know its position after 2 hrs.
The second car moves at a velocity of 20 km/hr – i.e it has a known direction as well as a known speed. After 2 hrs of travelling in a known direction, at a known speed, we can know its final position.
NOTE: (We ***do*** know the first car could be anywhere on a circle with a radius of 40 km surrounding the starting point.

(iv) This question is badly worded.

If we are talking only about Lu Reh’s journey **to** school on one day (not back as well), then we can talk about this journey in terms of: **displacement** (*from his home*), and the **speed** he travels at.

We can give both of these pieces of information together if we talk about his **velocity** – this tells us his speed and direction. This is the most complete description of his movement, so **(b)** is the best answer.

It is very unlikely that any human could move at a **constant speed**.

E. Acceleration

What do you know? – Answers: **(i)** yes **(ii)** yes

(iii) **This question is badly worded.** This should say it takes 10s for the ball to reach the ground. Before you let the ball drop it is not moving. The speed of the falling ball will ***increase*** because of the acceleration due to gravity.

ANSWERS TO EXERCISES:

(i) This question has a mistake. It should say 22 ms^{-1} or 22 m/s.
Answer: 22 – 4 = 18 ms^{-1}, 18/3 = 6 ms^{-2}.
Make sure your students use the correct units for acceleration!

(ii) This question has a mistake. Change to: 'A particle with an initial velocity of 102ms^{-1}……..'

Answer: - 102/12 = - 8.5. As the particle has **slowed down**, this is **deceleration**, i.e. the acceleration is **negative**. (Vf – Vi) = (0 – 102). The acceleration of the particle is - 8.5 ms^{-2}.

Review Exercises

(The English is badly worded in many of these)

i. Multiple choice: **1.** (c) **2.** (b) **3.** (d) **4.** (b) **5.** (a) **6.** (c)

ii. True or false: **1.** F **2.** T **3.** T **4.** T **5.** T

iii.

1. The small bird is moving at a greater speed.

600/60 = 10 ms^{-1}, 60/5 = 12 ms^{-1}

2. Kilometres per second - kms^{-1} - would be a good unit. Planets travel very fast – they go great distances in a short time. The kilometre is the biggest common unit for distance. The second is the smallest common unit for time. If we use these two together, the numbers will not be so big.

3. If the initial velocity is greater than the final velocity, this means that later the particle is going more slowly than in the beginning. The particle has **slowed down** or **decelerated**.

4. The students should show two or three examples each which show that distance travelled, and distance from the starting point are not always the same.

5. The increase in velocity is (34 – 18) = 16 ms^{-1}. This happens over a time period of 8 seconds, so the bird's acceleration is (16/8) = 2ms^{-2}.

Review Exercises (continued)

iv.

1. This question is wrong and has no meaning. Change to:

A car is driving round and round a field. You measure the time the car takes to drive around the field one time. What other measurements would you have to take to give:

(a) The speed of the car (b) If it is accelerating or decelerating (c) If it is moving at a constant speed

2. Total time for journey = 3 hrs. Total distance travelled = (1 x 80) + (2 x 40) = 160 km.
The average speed is (160/3) = 53.33 ms^{-1} (or 53 and 1/3 ms^{-1}).

3. No, the distance travelled and the displacement are not the same.

The distance travelled = (10 + 20) = 30 km.

We can calculate the displacement as the long side of a right-angled triangle using $A^2 = B^2 + C^2$.
$A^2 = (20^2 + 10^2) = (400 + 100)$. $A^2 = 500$. A = square root of 500.

Even if you don't have a calculator, you know that 30^2 (the square of the distance travelled) = 900. As the square of the displacement is only 500, you know the displacement must be less than the distance travelled. They cannot be the same.

v.

1. (**at rest** means not moving or stationary)
These are very bad questions. The units, speeds and distances are not realistic whether you use minutes or seconds.
Sometimes it will be easier to give the answers in metres per minute, rather than the usual metres per second.

1,000/2.5 = 400 metres per minute **or** 1,000/150 = 6.66 ms^{-1} (6 and 2/3 ms^{-1}).

2. This is a bad question. Change to 1 minute 6 seconds for time from A to B.

Use (Vf – Vi)/time. Use metres per second. Acceleration from point **A** = (6.66 – 0)/66 = 0.1 ms^{-1}.

3. This is a bad question. The meaning is not clear.
She completes the race from B to C at (1,000/156) = 6.4 ms^{-1}.
From A to B she is accelerating at (6.4 – 0)/90 = 0.07 ms^{-1}. There is no information to say that between A and C she slows down.

4. There is a mistake in this question. It should say 360 metres per minute.
For the first runner:
A to B + B to C = 1,500 m. Total time = (90 + 156) = 246 seconds or 4 minutes 6 seconds.
For the other runner: 1,500/360 = 4.167 minutes. 4.167 x 60 = 250 seconds.
The first runner ran the distance 4 seconds faster.

Chapter 2: Force

A. Understanding forces

B. Force, mass and acceleration

ANSWERS TO ACTIVITY 2.5:

1. 52 x 2 = 104 N

2. It will increase.

3. m = 80/4 = 20 kg

C. Friction and gravity

D. Weight, mass and volume

ANSWERS TO EXERCISES:

i. Force = mass x acceleration. Force = (10 x 5) = 50 N

ii. Weight = mass x acceleration due to gravity. 75 = m x 9.8. mass = (75/9.8) = 7.6 kg.

iii. This is a pointless question.
(On earth) 20/9.8 = approx. 2 kg. F = m x a, 20 = 2 x a, acceleration = (20/2) = 10 ms^{-2}.

iv. There is a mistake in this question – it should say 9 ms^{-2}.
Final velocity = 9 x 9 = 81 ms^{-1}.

E. Action and reaction

ANSWERS TO EXERCISES:

ii. Even though it has a smaller velocity, it can still have greater momentum because its mass is greater.

ANSWERS TO ACTIVITY 2.13:

1. Use M = m x v:

Before: Left hand ball, M = (0.4 x 2) = 0.8 kg ms^{-1}. Right hand ball, M = (0.4 x 0) = 0 kg ms^{-1}.
Momentum of L.H. ball + momentum of R.H. ball = 0.8 kg ms^{-1}.

After: L.H. ball, M = (0.4 x 0.5) = 0.2 kg ms^{-1}. R. H. ball, M = (0.4 x 1.5) = 0.6 kg ms^{-1}.
Momentum of L.H. ball + momentum of R.H. ball = 0.8 kg ms^{-1}.

2. Yes. The momentum before and after the collision is the same.

F. Force and pressure

ANSWER TO ACTIVITY 2.15:

Area of a circle = Pi x D. A high-heel shoe can have a diameter of about 1 cm, and an elephant's foot about 30 cm.

Area of high-heel shoe = (0.01 x 3.14) = 0.03 m^2. The woman has 2 feet.
Area of an elephant's foot = (0.3 x 3.14) = 9.4 m^2. The elephant has 4 feet.

Weight of woman = mass x gravity = (50 x 9.8) = 490N
Weight of elephant = (500 x 9.8) = 4900N

P = F/A

Pressure from two heels alone = 490/(2 x 0.03) = 8167 N/m^2. (This assumes no weight on the sole of the shoe, but only on the tiny heels)

Pressure from an elephant with 30 cm diameter feet standing on 1 leg = 4900/ 9.4 = 521 N/m^2.

Even though the woman weighs much less, because high heels are so small they can exert a lot of pressure on the small area they touch. Sometimes when people walk in high heels they can damage the floor surfaces in buildings.

Review Exercises

i. Multiple choice

1. (b) **2.** (a) **3.** (d) **4.** (c) – *(on Earth's surface)* **5.** (b) **6.** (d) **7.** (b) **8.** (b)

ii. True or False?

1. T **2.** F **3.** F? **4.** F *(should say '**on** an object')* **5.** F *(should say '**on** an object')*

6. This question is wrong – it has no meaning in English.
 - ***Weight** is a measure of the **force** exerted **on** a **mass** by **gravity**.* **7.** T **8.** T **9.** F

Review Exercises (continued)

iii.

1. Force = mass x acceleration. Units should be kg, ms^{-1}, and N.

2. Although the mass and weight are the same, the flat sheet has a greater surface area for air friction to act on, so the air friction will stop it from falling as fast as the sheet crumpled into a ball.

3. Yes – Newton's 3^{rd} Law.

4. 1 Pascal = 1 kg ms^{-1} m^2 or 1 N m^2. P = F x A, so 20 x 0.08 = 1.6 Pa

5. Because of the shape of the wing, the air moves more quickly over the upper surface. As the airflow is faster above the wing, the pressure will be lower above the wing.

6. Compare the density of the object with the density of water. If its density is greater than the density of water, it will sink; if its density is less than the density of water, it will float.

7. The mass of an object is constant. (Mass is a measure of the amount of material in an object.) Weight is the product of the mass of an object and the force exerted on that mass by gravity.

8. The children are pulling with equal force, so the toy does not move in either direction. As the **net force** = 0, then the movement will also = 0.

iv.

1. The greater speed of airflow above the upper surface of the kite reduces the pressure above the surface of the kite.

2. This is not a good question. Change to:
You are going fast downhill on your bicycle when your front wheel hits a very big rock, firmly stuck into the ground. Using the term **inertia**, explain what will happen to *your* movement.

3. Momentum = mass x velocity, so mass = momentum/velocity.
Mass = 0.2/10 = 0.02 kg, *or* 2 g.
Density = mass/volume, so density = 2/50 = 0.04 gcm^{-3}.

4. The ball cannot be solid steel - because the density of steel is greater than the density of water, we know a solid steel ball would sink in water. Perhaps the ball is hollow.

5. If you very accurately measure the volume and the mass of the coin, you can calculate the density of the coin, and compare this with the density of gold.

6. Change this exercise. This should say 'use arrow**s** to show the forces'. It should also suggest using differently shaped or coloured arrow to show any movement.