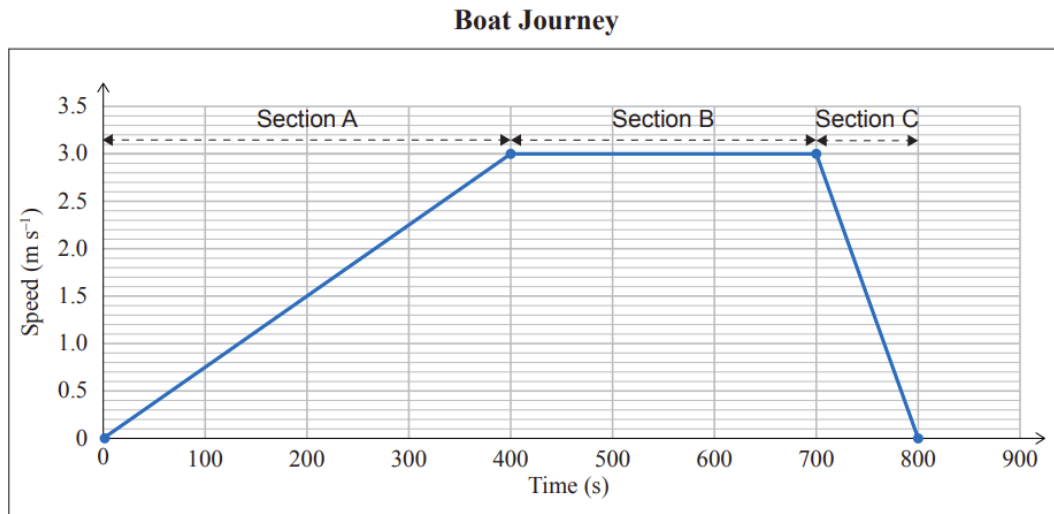## SCIENCE: 90940 DEMONSTRATE UNDERSTANDING OF ASPECTS OF MECHANICS: FORCES

2019:1

A boat travels across a lake to the start of a walking track. The graph below shows the boat's journey.

Boat Journey

(c)   Explain the acceleration and motion of the boat shown in Section B of the graph by discussing the horizontal forces acting on the boat.

2019:3

A parachutist with total mass of 63 kg jumps from a plane.

(c)   Explain the vertical motion of the parachutist immediately after jumping out of the plane (before the parachute opens). In your answer you should:

- describe the vertical motion of the parachutist

- describe the net vertical force, and state whether the force(s) are balanced or unbalanced

- explain how the net vertical force affects the vertical motion.

2018:2

Willow and her mountain bike have a combined mass of 82 kg.

She accelerates at the start of a race at 0.80 m s^{-2}.

(a)   Calculate the net force acting on the bike and rider when accelerating

(b)   (i)   Draw and label arrows on the diagram below to show ALL the forces acting on Willow and her bike when accelerating.

(ii)   Explain the size of the forces involved when Willow and her bike are accelerating.

2017:2

A lightweight waka ama (outrigger canoe) has a mass of 9.90 kg.

(a)   What is the difference between mass and weight? Use the waka ama as an example, and include a calculation for weight.

2017:3

A crane lifted a container 30 m in 15 s. The weight of the container is 60000 N

(c)   Referring to the force diagram below, explain the link between the vertical net force acting on the container, and the type of motion produced, *while the container is being lowered*.
In your answer, you should:
- describe what is meant by net force
- explain the link between the direction of the vertical net force and motion.
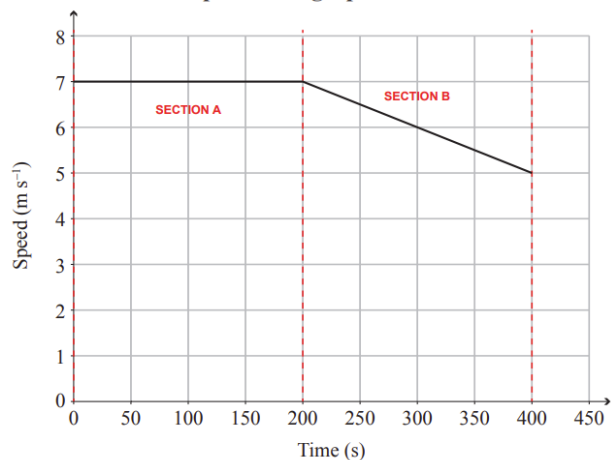
Force diagram
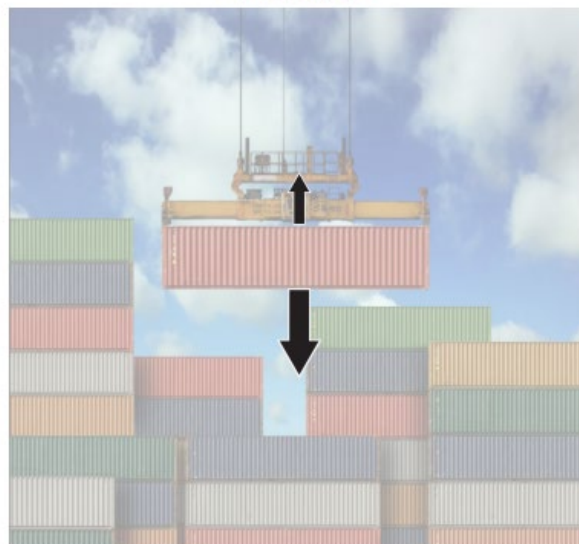
2016:2

A harvester was working in a paddock.

The speed-time graph shows the journey of the harvester.


Speed-time graph of a harvester

(b)   Explain how the forces acting on the harvester result in the motion shown in the graph (no calculations are needed). Include reference to the net force.

Section A:

Section B:

(d) A worker dragged a 25 kg bag of grain up the 3.5 m ramp to reach the height of 1.2 m. It took longer to drag the bag up the ramp than to lift the bag straight up to the top of the ramp.

3.5 m

1.2 m
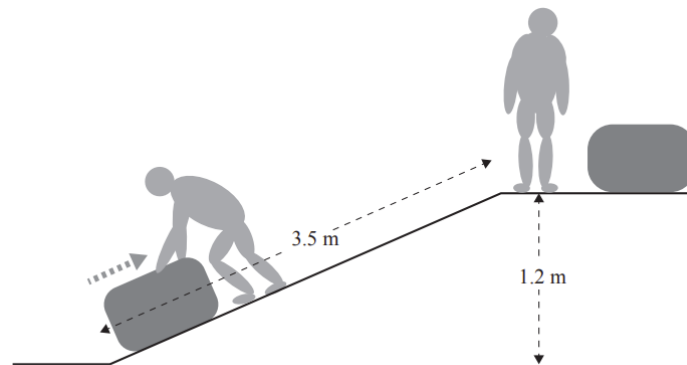
(i) Explain why the force needed to drag the bag of grain up the ramp to the top is less than the force needed to lift the bag straight up (vertically). Ignore friction.

2016:3

A small rocket has a mass of 2.60 kg and a weight of 26.0 N.

(a) Explain the difference between mass and weight.

(d) The rocket was fired again. After it reached its maximum height, it began to fall back to the ground. As it fell, a parachute was released. The graph below shows the speed-time graph of the rocket falling from its maximum height back to ground. Just after point 2, a parachute is released.

parachute released

2

3

1

Speed

rocket at maximum height   Time
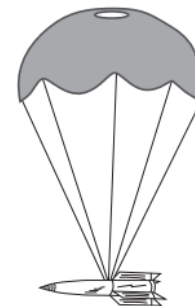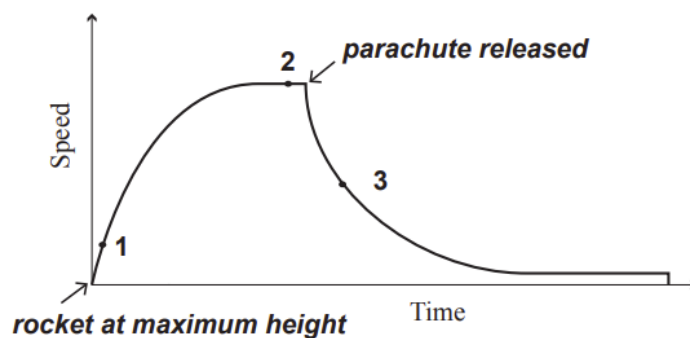
Discuss the change in speed at points 1, 2, and 3 as the rocket falls to the ground.
In your answer you should:
- describe the forces involved, and whether they are unbalanced or balanced
- explain what is causing the change in speed
- describe the frictional forces acting as the rocket falls.

2015:2

The kererū (also known as New Zealand wood pigeon or kūkupa) is one of the largest pigeons in the world.

(a) (i) Explain the difference between mass and weight.

(ii) Calculate the weight of a kererū that has a mass of 630 g.

(b)   The force diagrams below show another kererū flying at a constant speed, but then slowing down.
        Only horizontal forces are shown in these diagrams. Assume any other forces are balanced.
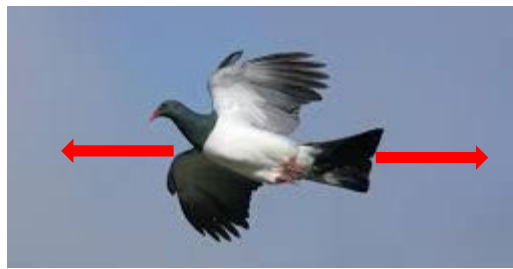
| constant speed | slowing down |

Referring to the force diagrams above, explain the link between the horizontal net force acting on the
bird, and the type of motion produced. In your answer you should:
*   describe what is meant by net force
*   explain the link between the horizontal net force and motion for each situation described
*   compare the direction of the horizontal net force and the direction of the motion for the bird in
    each diagram.

2014:1
A cyclist and bike have a combined mass of 99 kg.
(a)   Show that the combined weight is 990 N.

## 2014:2
(b)   The footstool was pushed around the house.

Select the correct statement below and then explain your choice.

A.   *It is easier to push the footstool across carpet than across a wooden floor.*
B.   *It is easier to push the footstool across a wooden floor than across carpet.*
Write the letter of the correct statement. Explain why you have selected this statement.

2014:4
(b)   (i)   On the photo below, draw and label ALL the forces acting on Zane's go-cart in **Section B** of the
                graph. The track is flat and horizontal.
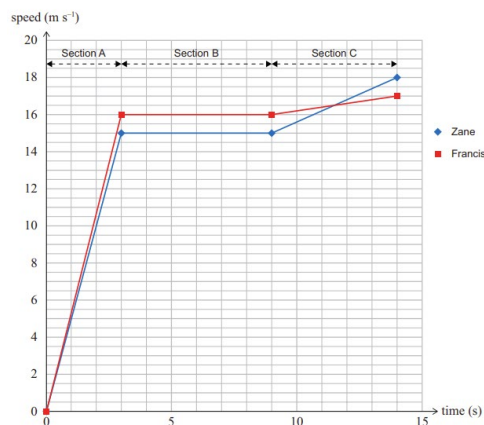
        Ensure that your labels show the relative sizes of the forces.

        (ii)   Discuss the forces that are acting on Zane's go-cart to explain its motion in Section B of the
                graph.

2013:1

(b)   A runner is accelerating (A), running at constant speed (B) and decelerating (C).
On the diagrams below, draw and label the thrust and friction forces acting on the runner in sections A, B, and C.
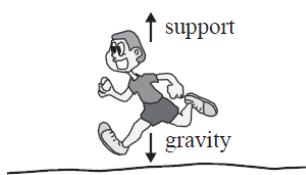In your answer you should:
- use arrows to show the directions of the thrust and friction forces
- beside each diagram, state if thrust is greater than friction, thrust is equal to friction, or if thrust is less than friction.
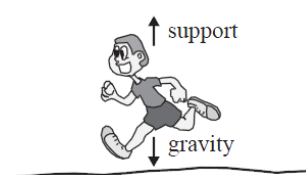
The gravity and support forces have been done for you.
(Note from NB2S: we recommend that the arrows touch the body of the runner – they should come from its centre of mass – and that the force acting downwards is labelled as weight or weight force).
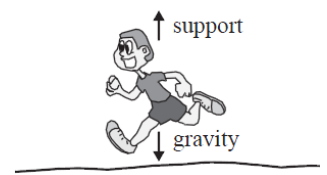
Section A   **Section B**   **Section C**

↑ support   ↑ support   ↑ support

↓ gravity   ↓ gravity   ↓ gravity

(c)   Referring to your force diagrams in part (b), explain the link between the net force acting on the runner in sections A, B, and C of the graph, and the type of motion.
In your answer you should:
- describe what is meant by net force
- explain the link between net force and motion for EACH section
- compare the direction of the net force and the direction of the motion for EACH section.

2012:3

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.

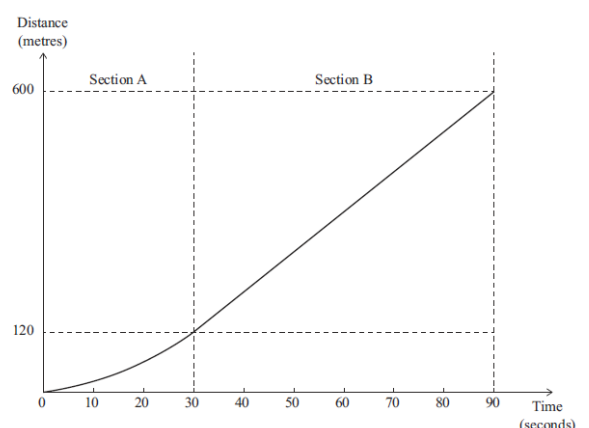**Golf ball**   **Table-tennis ball**

2 m   2 m

(a)   Calculate the **weight** of the golf ball.
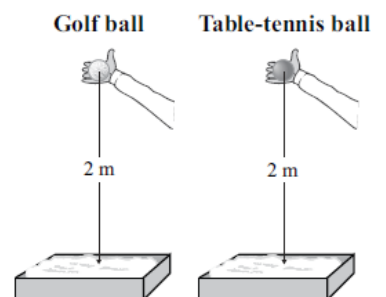
2012:1

A woman drives her tractor down a sandy beach to pick up her friend's boat. The distance-time graph below shows part of the journey.

(b)   Describe the **motion** of the tractor in **section B**, and explain what this tells us about the forces acting on the tractor during this time.

(c)   The total mass of the tractor and driver is 1660 kg. Calculate the **speed** of the tractor at the **end** of section A, and then calculate the **net force** acting on the tractor during **section A** of the graph.

Distance
(metres)

600 ┈┈┈┈┈┈┈┈┈┈┈┈┈┈┈

Section A   Section B

120 ┈┈┈┈┈

0   10 20 30 40 50 60 70 80 90   Time
(seconds)

QUESTION ONE: PARACHUTING (2011;1 – AS90940)

A parachutist of mass 75 kg jumps from a plane at a height of 4 000 m above sea level.

(b)   Explain the vertical motion of the parachutist **just after** she jumps out of the plane (before the parachute opens). In your answer you should:

- draw and label the vertical force(s) acting on the parachutist and show their relative sizes on the image to the right

- describe the net vertical force and state whether the force(s) are balanced or unbalanced

- describe the vertical motion of the parachutist

- explain how the net vertical force affects the vertical motion.

(c)   After the 60 seconds, the parachutist pulls the cord and opens her parachute.
Explain how the parachute **reduces** the speed of the parachutist when it is just opened. In your answer you should consider:

- how the motion of the parachutist changes when the parachute is opened

- the effect of the size of the parachute on the motion

- the effect of the parachute on the net vertical force.

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)

(a) The apple (m = 0.15 kg) falls to the ground in 0.78 s, hitting the ground with a speed of 6.3 m s^{-1}.

Complete the speed-time graph and use the graph to calculate the net force acting on the apple as it falls. Give an appropriate unit for force.
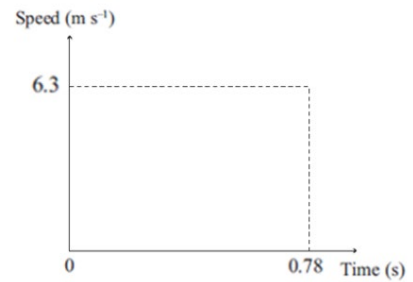
FORCES (2010:4 – AS90191)

A skateboarder is skating along a concrete path at a constant speed. As he approaches an intersection, he slows down and comes to a stop.

Discuss how the forces of friction and push change the skateboarder's speed.
In your answer you should:

- Draw in arrows on the diagram to show the relative sizes of friction and push on the skateboarder as he slows down.

- Describe the net force acting on the skateboarder as he slows down AND when he has stopped.

- State whether the net forces are balanced or unbalanced when the skateboarder slows AND when he has stopped.

- Explain why the net forces cause the skateboarder to slow and stop.


A CAR JOURNEY (2009:1 – AS90191)

The speed-time graph represents part of the journey of a car.
The motion of the car is different between section A and section B.

(a) Use the mass of the car (m = 1200 kg) and information from the graph to calculate the net force acting on the car in section A and in section B. Include the unit in your answer.

(b) Discuss the forces that act on the car in sections A and B and explain how they affect the motion produced. In your answer you should:
- State whether the forces are balanced or unbalanced in each section, and describe the resulting motion of the car in each section
- Explain why the net force results in the different type of motion described in each section.
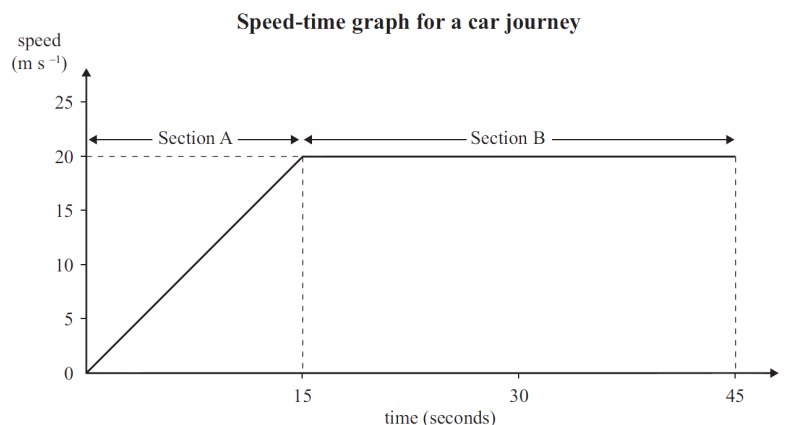
A REMOTE CONTROL CAR (2008;2 – AS90191)

(d)   A child plays with a remote control car on concrete. The car accelerates from rest, and then travels at a constant speed of 4 m s^{-1}. The car drives off the concrete onto some sand, and its speed rapidly decreases. Discuss why the car's speed rapidly decreases as it drives onto the sand. You should consider:
- the push force and the friction force acting on the car
- which force(s) have changed and why
- the net force.

The speed-time graph represents the motion of the car from its starting point to when it stops.
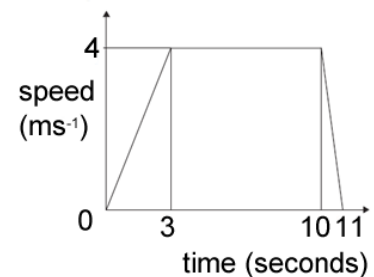
(e)   The mass of the car is 400 g (0.4 kg). Calculate the net force acting on the car between 0 and 3 seconds. Give the correct unit with your answer.

SPORTS TRAINING (2007;1 – AS90191)

The speed-time graph represents sprint training for an athlete.

(d)   Describe the relationship between the push force and the friction force during the 8 seconds that the athlete is accelerating.

(f)   When sprinting, the athlete wears sport shoes with spikes like the ones shown below.
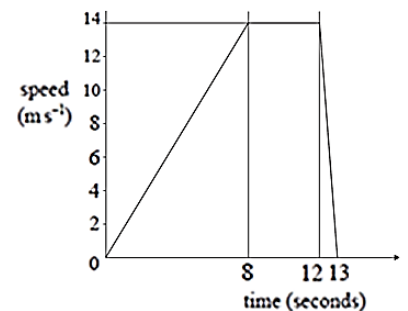
Explain how the effect of the spikes on the sport shoes changes the effect of forces acting on the athlete and how this leads to an improvement in performance.

(h)   Another part of the athlete's training is swimming. On the diagram below, draw and label arrows to show the directions of the following four forces:

gravity,   support,   push   and   friction

CYCLING (2006:1 – AS90191)
Toni cycles each day on her mountain bike. Four forces act on Toni and the bike while she rides: weight, support, friction and push.

(f)   On the diagram draw in arrows to show the directions of ALL FOUR forces acting on Toni and the bike. Label the forces.
(g)   The four forces in the diagram add together to give a net force of zero. Explain why a net force of zero would result in Toni and the bike moving at a constant speed.

(h)   Toni reduces her speed from 8.3 m s^{-1} to 0 m s^{-1} in 180 seconds to come to a stop. Explain what must happen to the forces involved, to reduce Toni's speed.

While travelling home, the bike accelerates at 1.5 m s^{-2} over a distance of 25 m as shown in the diagram (not to scale).

1.5 m s^{-2}

25 m
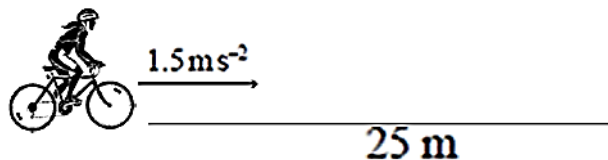
(i)   Toni and the bike have a mass of 70 kg. Calculate the net force acting on the bike when it is accelerating.

TANDEM SKYDIVING (2005:1 – AS90191)

Ariana wins a competition for a Tandem Skydive. The plane flies to a height of 5000 m above sea level. Ariana is strapped to her jumpmaster. Ariana and the jumpmaster have a combined mass of 150 kg.

(a)   Using the equation $F_{gravity} = mg$ find the combined weight of Ariana and the jumpmaster.

(c)   Ariana and the jumpmaster jump out of the plane. One force acting on Ariana and the jumpmaster is gravity. Name the other force acting on them and state the direction in which it acts.

(d)   During the first 10 seconds the net force acting on Ariana and the jumpmaster is 825N. Calculate the net acceleration of Ariana and the jumpmaster. Include an appropriate unit.


After 60 seconds the jumpmaster pulls the cord and releases the parachute.

(e)   Discuss how the parachute reduces the speed of Ariana and the jumpmaster.
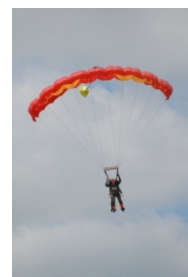
The speed-time graph shows the motion of Ariana and the jumpmaster from when they leave the plane until after the parachute is released.

(g)   Between 10 and 60 seconds Ariana and the jumpmaster's speed remains constant. Explain what the constant speed tells us about the two forces acting on them as they fall.

(h)   Calculate how far Ariana and the jumpmaster fell during the first 60 seconds.

Speed-time graph for Ariana's tandem skydive

Speed (ms^{-1})

Time (s)
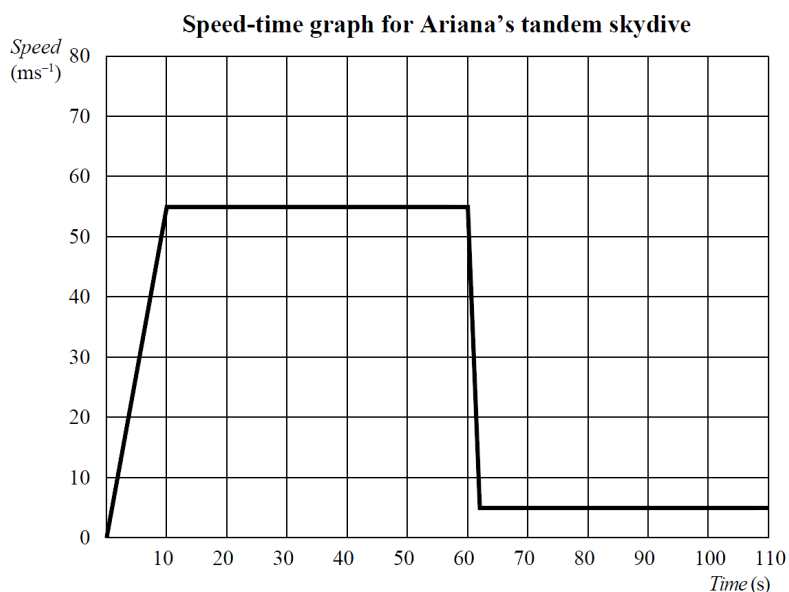
THE GAME CONTINUES (2004;3 – AS90191)

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

(a)   At its highest point, TWO vertical forces act on the ball. On the diagram below, use arrows to draw and name these two forces.

(b)   Explain whether the forces are balanced or unbalanced at the highest point.

PLEASE NOTE: Questions (a) and (b) in the question set by the NZQA above are ACTUALLY <u>INCORRECT</u> ONLY ONE VERTICAL FORCE ACTS (WEIGHT) AND THE FORCE<u>S</u> ARE NOT BALANCED OR UNBALANCED BECAUSE THERE IS ONLY <u>ONE</u> FORCE*

QUESTION TWO (2003:1 – AS90191)

A group of friends have decided to help in the school stage production.

(a)   William helped the sound technician to bring in boxes of sound gear. The boxes were pushed across the stage. On the diagram, draw arrows to show the direction of the FOUR forces acting on the box. Label the arrows you draw.
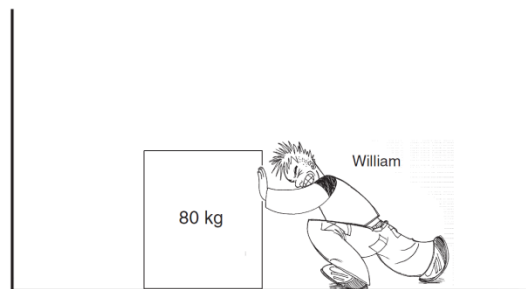
(d)   William pushes a speaker cabinet up a ramp to the stage. He starts by standing still at the bottom of the ramp and reaches a speed of 3 m s⁻¹ after 2 seconds. The speaker cabinet has a mass of 40 kg. Calculate the force that William uses to accelerate the cabinet up the ramp. Show all working. The units are required.