MECHANICS: MOTION QUESTIONS

IN TOWN (2020;1)

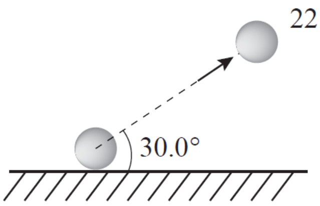
Alex and Jo have decided to take a road trip. They start from rest on a straight road and accelerate at 4.2 m s^{-2}.

(a) Show their velocity after 0.60 seconds is 2.5 m s^{-1}.

(d) While travelling at 50 km h^{-1}, Jo sees a pothole in the road 15 m ahead. She must reduce her speed from 50 km h^{-1} to 20 km h^{-1} to avoid damaging the car. If the time needed for safe braking from 50 km h^{-1} to 20 km h^{-1} is 2.3 seconds, show by calculation whether there is enough time to complete braking before reaching the pothole. You should start by showing that 50 km h^{-1} = 13.89 m s^{-1}.

THE HOCKEY MATCH (2019;1)

Nicole is playing for her school hockey team. During the game she passes the ball to her teammate Josie, who is some distance away. To do this she has to raise the ball high enough to give it flight and low enough to keep it safe. She hits the ball with a velocity of 22 m s^{-1} at an angle of 30°.



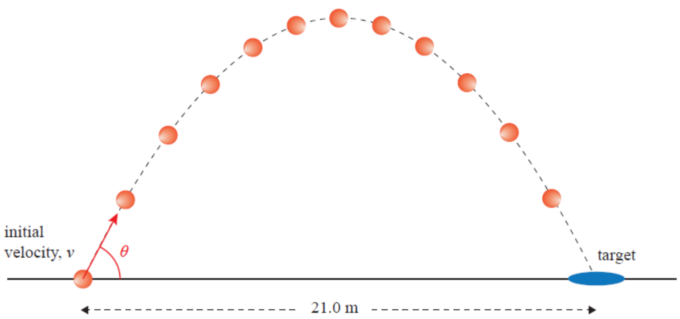
(a) Show that the initial vertical velocity of the ball is 11 m s^{-1}.

(b) Describe and explain the motion of the ball. You should refer to any forces acting on it as it moves through the air. You may include a diagram to support your explanation.

(d) Josie was 44 m away from Nicole when Nicole passed the ball to Josie in parts (a) and (b). Will the ball reach Josie before it bounces? Justify your answer using appropriate calculations.

PROJECTILE MOTION (2018;3)

A water balloon is launched, travelling a horizontal distance of 21.0 m. The water balloon is in the air for 2.80 s.



(a) Calculate the horizontal velocity of the balloon.

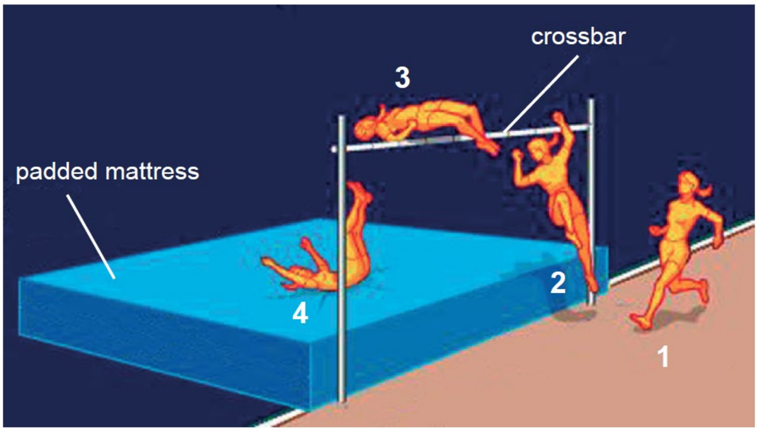
(b) Show that the initial velocity of the water balloon is 15.6 m s^{-1}.

(c) If the same water balloon was launched at the same initial velocity on ‘planet X’ where the acceleration due to gravity (g) was 3.7 m s^{-2}, would the water balloon go the same horizontal distance? Clearly explain your answer.

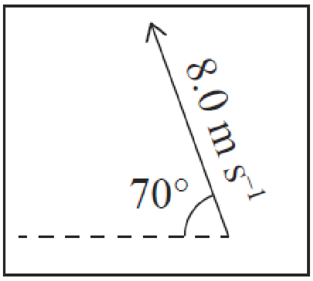
(d) Back on earth, Jimmy wants to catch a water balloon. He stands 12.5 m from the launch position, and his hands are 1.1 m above the top of the launcher. The water balloon is launched at an angle of 35.0° to the horizontal. The horizontal component of the velocity is 10.0 m s^{-1}. By first showing that the vertical component of the velocity is 7 m s^{-1}, determine if the water balloon will arrive at the right position for Jimmy to catch it.

High Jump (2017;2)

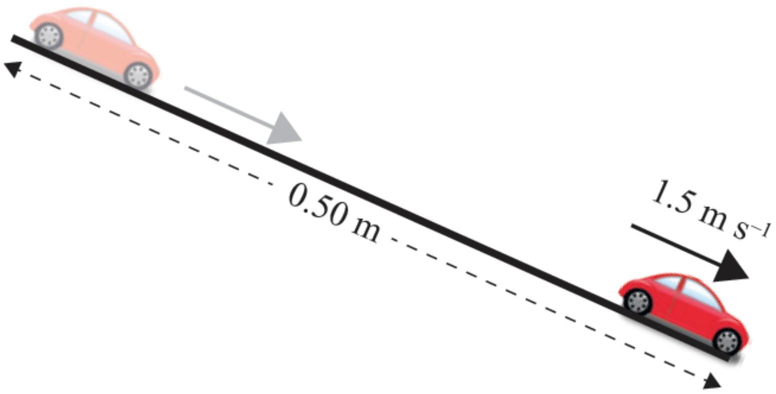
Sarah, a 55.0 kg athlete, is competing in the high jump where she needs to get her body over the crossbar successfully without hitting it. Where she lands, a padded mattress cushions her fall.



(b) During one of the jumps, the initial velocity of Sarah, at take-off, is 8.0 m s^{-1} at an angle of 70° to the horizontal. Calculate the time it takes for Sarah to reach the maximum height – position 3 in the diagram above.



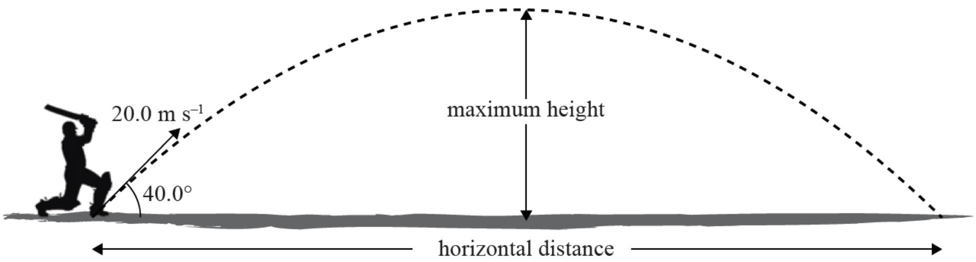
Motion (2016;1)



(a) Sarah releases a red car, from rest, down a slope of length 0.50 m. The red car accelerates steadily and reaches a speed of 1.5 m s^{-1} when it gets to the bottom of the slope. Calculate the acceleration of the red car as it moves down the slope.

Projectile Motion (2016;2)

During a cricket game, a batsman hits the ball at an angle of 40.0° with the ground at a velocity of 20.0 m s^{-1}, as shown below.



(a) Show that the initial vertical component of the ball's velocity is 12.9 m s^{-1}.

(b) Calculate the time it takes the ball to reach its maximum height.

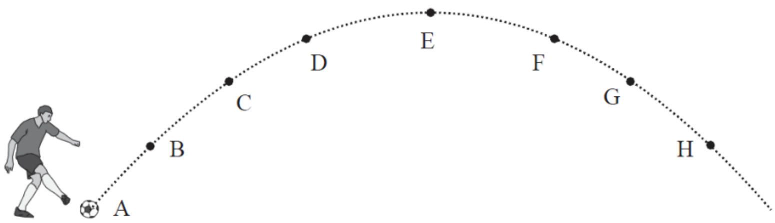
(c) Calculate the horizontal distance travelled by the ball before it hits the ground.

(d) Give a comprehensive explanation of the effect of the force(s) acting on the ball during its flight. Assume air resistance is negligible. In your answer, you should:

- describe the horizontal motion
- discuss the effect of force(s) on horizontal motion
- describe the vertical motion
- discuss the effect of force(s) on vertical motion.

Projectiles (2015;1)

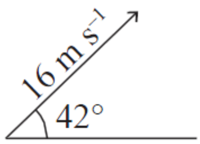
Roy kicks a ball. The diagram shows the trajectory of the ball. You may assume air resistance to be negligible.



(a) On the diagram draw **labelled arrows** of **appropriate length** to show the following:

- the force on the ball at position C and at position G
- the horizontal component of the velocity of the ball at position B and at position H
- the vertical component of the velocity of the ball at position D and at position F.

(b) The ball is kicked with an initial velocity of 16 m s ^{1}, at an angle of 42° to the ground. Calculate the initial horizontal and vertical components of the velocity of the ball at position A.



(c) State the horizontal and vertical components of the velocity of the ball at position E. Explain your answers.

(d) Calculate the horizontal distance the ball travels before returning to the level from which it was kicked.

Shamilla drives to the Gym (2014)

Shamilla and her car have a combined mass of 1100 kg.

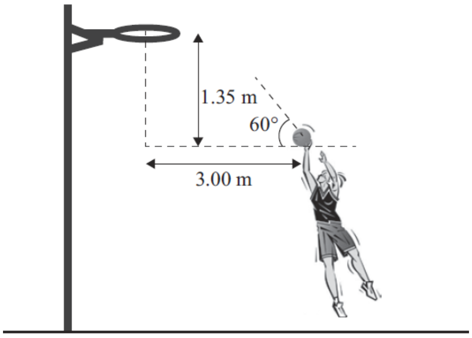
(c) Shamilla's car accelerates from a speed of 2.0 m s^{-1} to a speed of 22.0 m s^{-1}, covering a distance of 72 m. Calculate the size of the average net force on the car while it accelerates.

Motion (2013;1)

Jason spends a day at an amusement park.

(c) Jason then goes for a ride on a go-kart. Towards the end of the ride, he decelerates at 2.5 m s^{-2} and comes to a stop in 4.2 seconds. By calculating Jason's initial velocity, determine the distance he travels while coming to a stop.

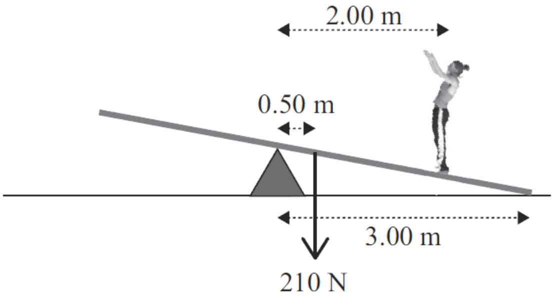
Forces and Motion (2013;2)



(d) On another occasion, Hillary stands 3.0 metres from the hoop. She throws a ball with an initial velocity of 6.5 m s^{-1} at an angle of 60° to the horizontal. The hoop is 1.35 m above the bottom of the ball when it is thrown initially.

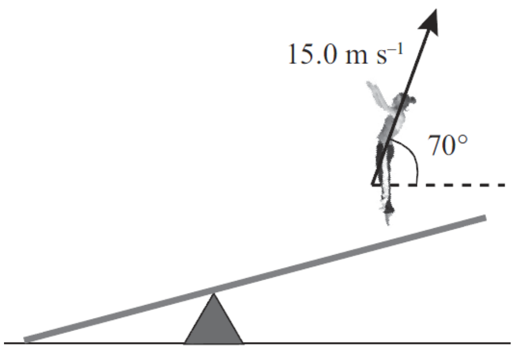
Carry out calculations to determine whether or not the ball will go through the hoop. Begin your answer by calculating the horizontal and vertical components of the initial velocity of the ball.

THE SEE-SAW (2012;2)



In their next act, Hannah (55 kg) stands on a see-saw. The see-saw has a weight of 210 N.

Jess drops vertically onto the other end, causing Hannah to be thrown into the air. When Jess lands on the see-saw, Hannah is thrown into the air at a speed of 15.0 m s^{-1}, at an angle of 70° to the horizontal as shown in the diagram.



Calculate the time that Hannah takes to reach the highest point of her trajectory.

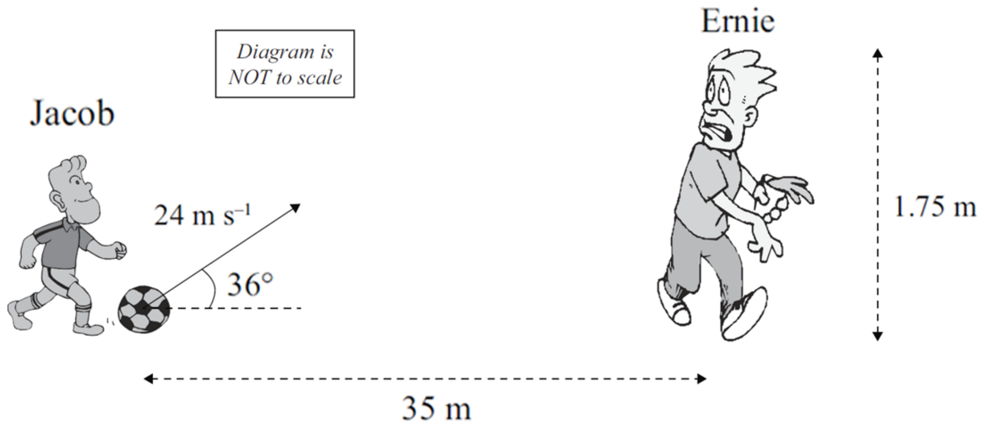
(c) When Hannah takes off, the horizontal component of her velocity is 5.1 m s^{-1}.
State the **size** and **direction** of her velocity at the highest point. Explain your answer.

THE BIKE RIDE (2011;1)

(a) Jacquie is a bike rider. One morning she starts riding from rest and accelerates at 1.2 m s^{-2} for 14 seconds. Show that her final velocity after 14 seconds is 16.8 m s^{-1}.

ENERGY AND PROJECTILE MOTION (2011;3)

(c) Ernie's son Jacob kicks a ball towards Ernie in the garden. Ernie is 1.75 m tall. Jacob kicks the ball with a velocity of 24 m s^{-1} at an angle of 36° to the ground. Jacob is standing 35 m away from Ernie.



Will the ball hit Ernie or go over his head? In your calculations, you should start by showing that the horizontal component of the initial velocity of the ball is 19.4 m s^{-1}.

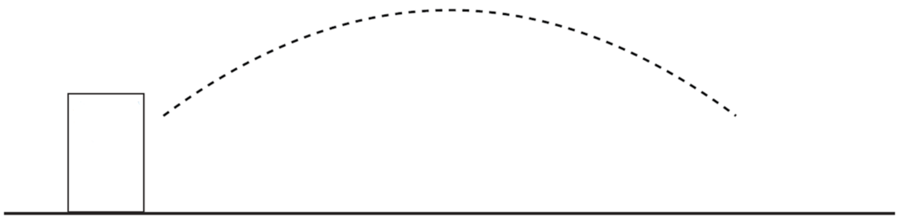
THROWING THE DISCUS - PART 2 (2010;2)

James releases the discus at an angle of 37° to the horizontal.

(a) Describe the energy changes as it **rises**, **falls,** lands and **rolls**, coming to a stop. You may ignore any forces caused by the air.

(b) State the **size and direction of the acceleration** of the discus at the highest point of its trajectory.

(c) It takes 2.4 s to return to the height at which it was released, as shown in the diagram. (James releases the discus at an angle of 37° to the horizontal.)



Calculate the speed at which he releases the discus.

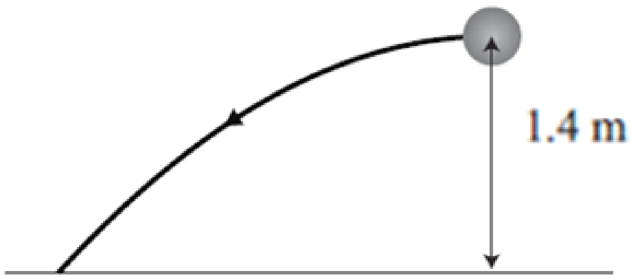
(d) In fact, there is a vertical force acting upward on the discus called lift. Explain how this lift force would affect the horizontal distance travelled by the discus.

RELATIVE VELOCITY AND PROJECTILES (2009;2)

Jordan goes to basketball practice. Jordan throws a basketball vertically upward.

(c) Describe and explain what happens to the velocity and acceleration of the ball while it is in the air.

(d) Jordan then throws the basketball horizontally, with an initial horizontal velocity of 7.8 ms^{-1}, at a height of 1.4 m from the floor.



Calculate the velocity (magnitude and direction) of the ball just before it hits the floor.

THE SOCCER MATCH (2008;1)

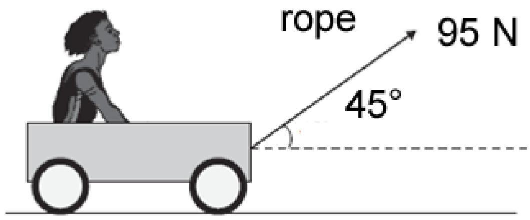
Louise is playing soccer for her 1st XI soccer team. Louise has a mass of 65 kg.

(a) Louise is running towards the goal at 8.0 ms^{-1}. She slows down to 6.0 ms^{-1} in 3 s. Calculate the distance she travels over the 3 s. Write your answer to the correct number of significant figures.

(b) State the main energy change when she is decelerating.

(c) Calculate her kinetic energy while she is running at 8.0 ms^{-1}

GOING TO THE PLAYGROUND (2008;2)



Rua then climbs onto a trolley and Tahi tows him with a rope, as shown in the diagram. Rua's mass is 65 kg, the mass of the trolley is 11 kg.
The tension force in the rope attached to the trolley is 95 N, and the rope is at an angle of 45° to the ground. There is a 35 N friction force on the trolley.

(m) After a while, Rua is rolling at constant speed. He throws a ball vertically upwards (relative to the trolley). Air resistance is negligible. Where will the ball land? Explain your answer.

(n) Rua throws the ball vertically at 9.8 ms^{-1}. Calculate how long it takes the ball to return to the same level.

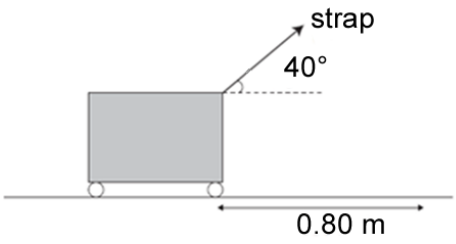
THE AIRCRAFT (2007;1)

An aircraft is flying at a height of 600 m above the ground.

(d) While landing, the speed of the aircraft reduces from 80.0 ms^{-1} to 25.0 ms^{-1} in 8.0 seconds. Calculate the size and direction of the acceleration. Express your answer to the correct number of significant figures.

THE BAGGAGE SECTION (2007;3)

(d) A suitcase is on wheels. The owner pulls it across the floor with a strap as shown in the diagram below. The force applied to pull the suitcase is 25 N and the strap is at an angle of 40° to the horizontal.
Calculate the work done pulling the suitcase 0.80 m along the floor.



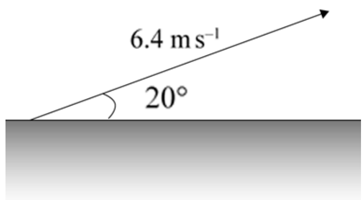
ROWING (2006;1)

Steve is in a rowing race. The total mass of Steve and his boat is 120 kg.

(a) At the beginning of the race, he is at rest. When the race starts, he accelerates to a speed of 4.5 ms^{-1} in 5.00 s. Calculate his acceleration. Write your answer to the correct number of significant figures.
(b) Calculate the distance Steve travels in the first 5.00 s.
(c) Calculate the minimum average power Steve must produce to cause this acceleration. Write your answer with the correct unit.
(d) Explain clearly why the average power Steve must actually produce will be greater than that which you calculated in (c).
(e) Later in the race, the boat is moving at constant velocity. Determine the size of the net (or total) force acting on the boat.

PROJECTILE MOTION (2006;3)

Marama is a long-jumper. She runs down a track, and jumps as far as she can horizontally. Her take-off velocity is shown in the diagram below (You can assume there is no air resistance, acceleration due to gravity = 9.8 ms^{-2}).



(a) Show that the horizontal component of her initial velocity is 6.0 ms^{-1}.
(b) Show that the vertical component of her initial velocity is 2.2 ms^{-1}.
(c) Calculate the distance she jumps horizontally.
(d) State the size and direction of her acceleration at the highest point.
(e) Explain why the horizontal component of her velocity is constant.

TRAVELLING BY CAR (2005;1)

(a) A car starts from rest at some traffic lights and accelerates in a straight line to a speed of 50.0 kmh^{-1} in 10 seconds. Using the approximation that 50.0 kmh^{-1} = 13.9 ms^{-1}, show that the car's acceleration is 1.4 ms^{-2}.

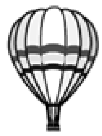
(b) The mass of the car and its occupants is 1357 kg. Calculate the net force acting on the car when it is accelerating.

(c) State whether the force that you calculated in your answer to (b) is equal to, less than or greater than the total driving force provided by the car's engine.

(d) Explain clearly the reason for your answer to part (c).

(e) Calculate the car's power output during the first 10 seconds of its motion. Give the correct unit for your answer.

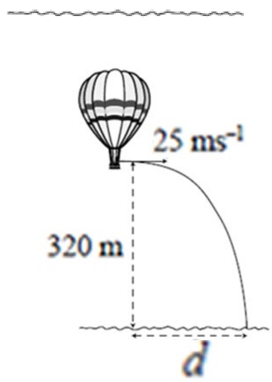
TRAVELLING IN A HOT AIR BALLOON (2005;3)



A hot air balloon is rising vertically at a constant speed of 2.5 ms^{-1}.

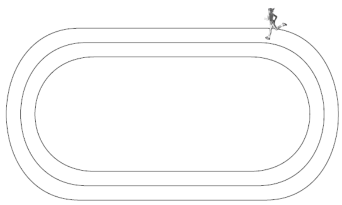
(a) Compare the sizes of the total upward force acting on the hot air balloon with the total downward force acting on it, giving your reasons.

Sometime later, the hot air balloon is hovering in a stationary position, 320 m above the sea. One of the passengers throws a tennis ball with a speed of 25 ms^{-1} in a horizontal direction as shown in the diagram below.



(b) Assuming that it was a calm day with no wind, calculate the horizontal distance d from the balloon to where the ball lands in the sea.

SCHOOL SPORTS – RUNNING (2004;1)



Ana runs a 400 m race around the school track in 65 seconds.

(a) Calculate Ana's average speed for the race.

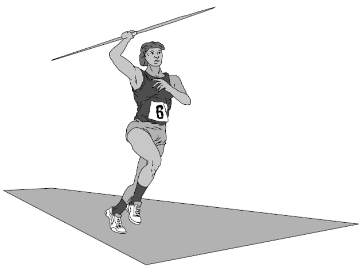
(b) At the start of the race, Ana accelerates to a speed of 6.0 ms^{-1} during the first 2.2 seconds. Calculate her acceleration, assuming it is constant.

(c) Calculate the distance that Ana travels during these first 2.2 seconds.

(d) During the middle part of the race, Ana, who's mass is 55 kg, is running at a steady speed of 6.5 ms^{-1}. Calculate her kinetic energy at this point in the race. State the unit for your answer.

(e) At the end of sports day, Ana drives home. During part of her journey, her car travels horizontally along a straight road for 40 m at a constant speed of 15 ms^{-1}. At this speed the car engine produces 6000 W of power. Calculate the size of the force needed to keep the car moving at this speed.

SCHOOL SPORTS – JAVELIN (2004;2)

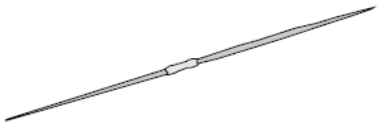


Where needed, use $g = 10.0\ ms^{-2}$.

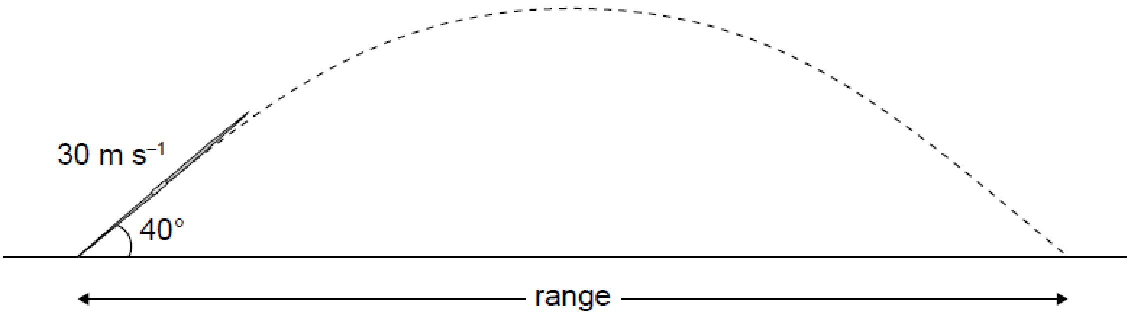
Joe is taking part in a javelin competition. The javelin behaves like a projectile.

(a) Name the shape of the path of the javelin.

(b) Ignoring air resistance, draw arrow(s) on the drawing of the javelin below to show the force(s) acting on it when it is in the position shown. Name the forces.



Joe now throws the javelin into the air at an angle of 40° above the horizontal at an initial velocity of $30\ ms^{-1}$.



(c) Show that the horizontal component of the initial velocity of the javelin is $23\ ms^{-1}$.

(d) Calculate the range (horizontal distance travelled) of the javelin under these conditions.