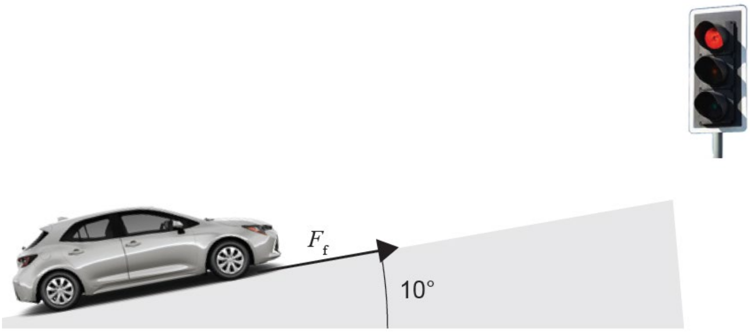
MECHANICS: VECTORS QUESTIONS

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}.

(b) While waiting at traffic lights, Jo has to put on the handbrake to stop the car rolling down the steep (10°) slope they are on. The mass of the car and occupants is 1600 kg. The diagram shows the friction force acting between the tyres and the road.



(i) Add labelled arrows to show the other two forces acting on the stationary car.

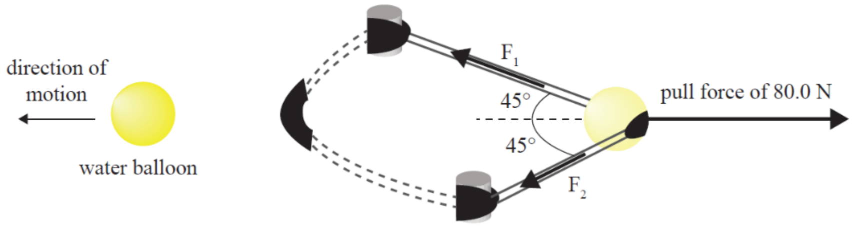
(ii) Complete a labelled vector diagram showing how all three forces add together.

(c) By first working out the force of gravity on the car, show that the value of the friction force required to keep the car stationary is 2700 N.

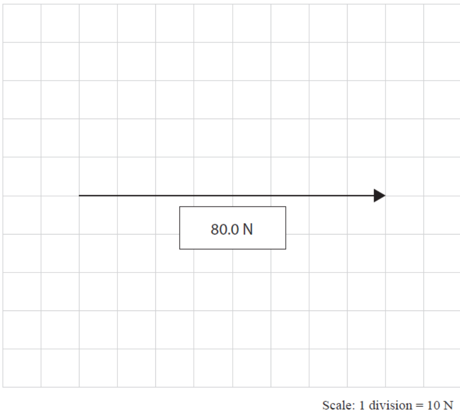
THE WATER BALLOON LAUNCHER (2018;1)

A water balloon launcher is made from stretchy rubber that approximates a spring, as shown in the photos below.

(b) Oliver then connected both sides of the water balloon launcher as shown. The launcher was held stationary with an 80.0 N pull force. The free body force diagram of the launcher is shown below.



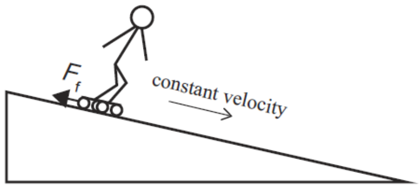
Draw a closed labelled **scale** vector diagram on the grid below. The 80.0 N horizontal force vector has been drawn for you.



Using the above grid or another method, calculate the magnitude of force F_1.

ROLLER SKATING (2017;1)

(a) Katy goes down a carpeted ramp at a constant velocity. On the diagram below, the friction force, F_f, between her skates and the carpet is shown.

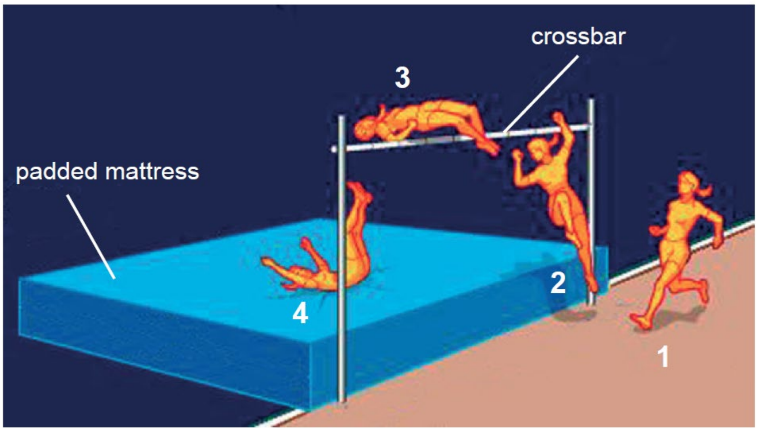


(a) Draw and name all other forces acting on Katy.

(b) In the box below, draw a closed vector diagram, showing that forces acting on Katy are balanced. Name each force.

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.



(a) Calculate the size of the force(s) acting on Sarah just after the take- off, in position 2 in the above diagram.

Draw an arrow(s) in the box to show the direction(s) of the force(s).

Janet's car and springs (2015;3)

Janet arrives home. She parks the car on a slope that is at 12° to the horizontal, as shown in the diagram

(a) Draw **labelled arrows** to show the **individual forces** acting on the car.

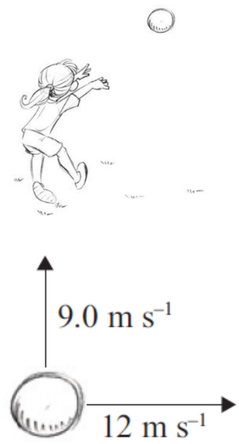
(b) Explain in terms of forces acting on the car, how the car remains stationary on the slope. You may draw a vector diagram to help your explanation.

(c) The mass of the car is 1500 kg. Carry out calculations to show how forces keep the car stationary while it is parked on the slope. You may draw a vector diagram to help your calculation.

Basketball (2014;1)

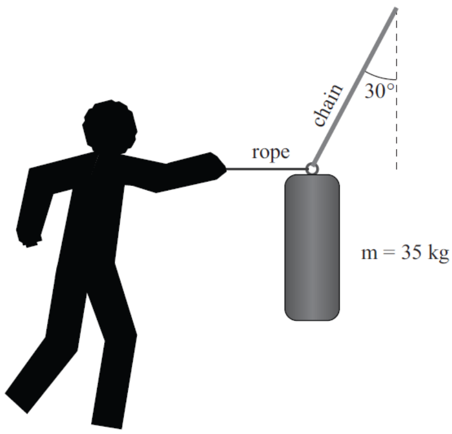
(c) Rachel throws the ball so it has a vertical component of velocity of 9.0 m s^{-1} and a horizontal component of velocity of 12 m s^{-1}, as shown in the diagram.

State the size of the vertical component of velocity AND the horizontal component of velocity when the ball reaches the highest point. Explain your answer.



At the Gym (2014;2)

(c) After doing some weights, Jamie goes across to the punch-bag, which is a large bag hanging from a chain. The bag has a mass of 35 kg. Jamie pulls the bag horizontally, using the rope tied to a ring at the top of the bag, until the chain is at an angle of 30° to the vertical, as shown in the diagram. Draw the three forces acting on the ring at the top of the bag. By drawing a vector addition diagram of the three forces acting on the ring at the top of the bag, determine the size of the tension force on the chain.

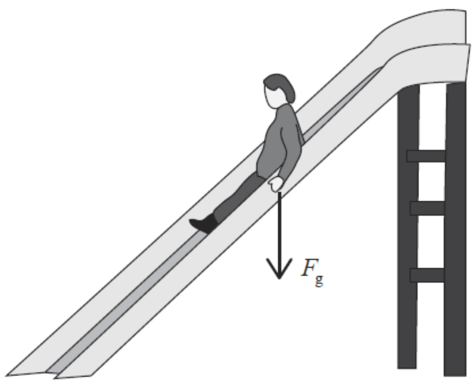


Motion (2013;1)

Jason spends a day at an amusement park.

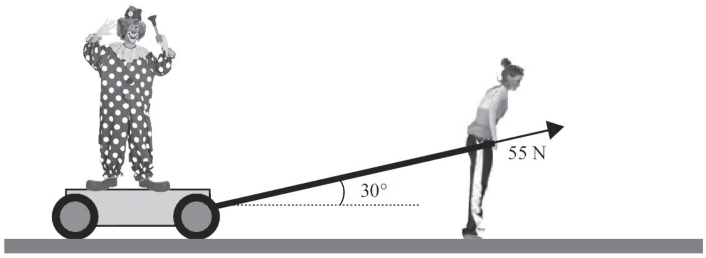
(d) Jason sits on a slide, as shown in the diagram. Jason has a mass of 65 kg. He is sliding down at constant speed.

(i) State the size of the net force on Jason.
(ii) On the diagram, draw the remaining forces (as labelled vectors) acting on Jason. F_g has been drawn for you.



CHARLIE THE CLOWN (2012;4)

The Clown makes his entrance riding on a cart pulled by Hannah. The clown and cart have a combined mass of 85 kg. The handle of the cart makes an angle of 30° to the horizontal as shown in the diagram below. Hannah applies a force of 55 N to the handle.



(a) Calculate the size of the **horizontal component** of the force on the handle.

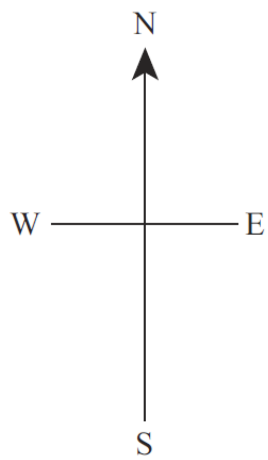
(b) The cart is in equilibrium.

- State what "equilibrium" means in terms of the forces acting.
- Describe what it tells you about the velocity of the cart.
- On the diagram above, draw **labelled arrows** showing the direction of any non-vertical forces acting on Hannah.

(c) Explain how Hannah can make the cart and clown accelerate **without** changing the **size** of the force she exerts on the handle. (Reducing friction is not a possibility.)

THE BIKE RIDE (2011;1)

(b) Jacquie, the bike rider, heads East at a constant speed of 16.8 m s^{-1}, then turns left (heads North), **without changing speed**. Draw a **vector diagram** and use it calculate the **change in her velocity** (size and direction).



(c) Jacquie takes her bike on a boat across a river 65 m wide. The boat heads straight across (↑) the river, with a speed of 6.8 m s^{-1} relative to the water. The current (→) causes the boat to land 15 m downstream. Calculate the speed of the boat relative to the bank (ground). You may begin your answer by drawing labelled vector diagrams for distances and speeds.

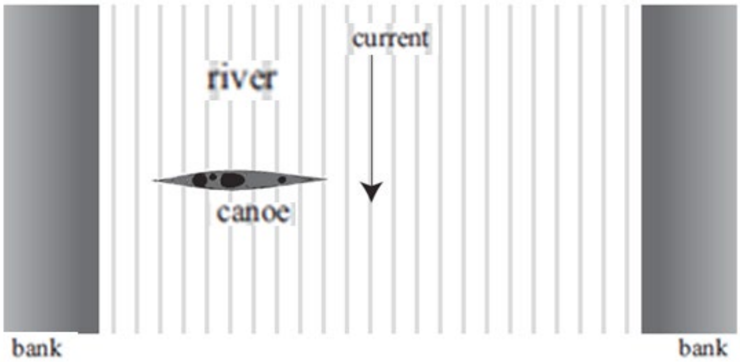
ENERGY AND PROJECTILE MOTION (2011;3)

(a) Jacquie's brother Ernie is pushing a lawn mower with a force of 26 N at an angle of 34° to the ground, as shown.

Explain fully why not all of the 26 N force exerted by Ernie is used to push the lawn mower horizontally along the ground.

RELATIVE VELOCITY AND PROJECTILES (2009;2)

Jordan uses a canoe to cross a river that is 45 m wide. There is a current flowing with a speed of 0.67 m s^{-1} as shown in the diagram. Jordan paddles with a speed of 1.39 m s^{-1} relative to the water. Jordan wants to paddle the canoe so it moves at right angles to the bank and lands straight across from where it started.

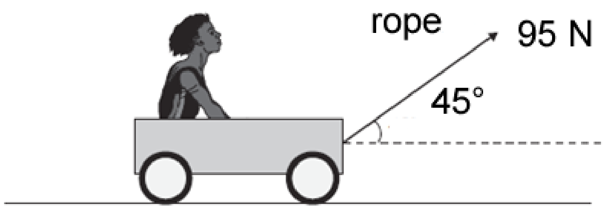


(a) Draw a labelled vector diagram showing the direction Jordan must point the canoe, in order to land straight across on the other side. Your diagram should have each of the following named clearly: the velocity of the current, the velocity of the canoe relative to the water, the velocity of the canoe relative to the ground (No calculations are necessary).

(b) Jordan points the canoe so that it lands straight across from where it started. Calculate the time it takes to cross the river.

GOING TO THE PLAYGROUND (2008;2)

Rua then climbs onto a trolley and Tahi tows him with a rope, as shown in the diagram below. 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.



(k) Calculate the size of the trolley's acceleration.

THE AIRCRAFT (2007;1)

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

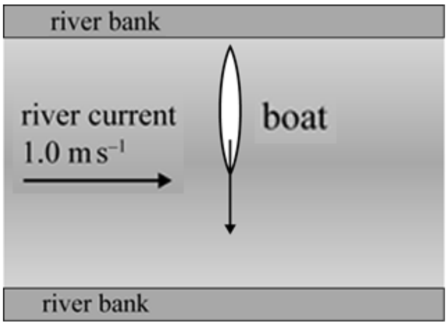
(a) Explain why the aircraft flying is not an example of projectile motion.

(b) While the aircraft is flying horizontally at a speed of 35 m s^{-1}, a packet is dropped from it. Calculate the speed of the packet when it reaches the ground (include a vector diagram).

(c) The aircraft has a new constant horizontal airspeed of 100 m s^{-1}. The pilot wants to fly directly east, but there is a wind blowing from the north with a speed of 40 m s^{-1}. Draw a labelled vector diagram showing the direction in which the pilot must point the aircraft. Use the diagram to calculate the angle between the aircraft and north (the bearing).

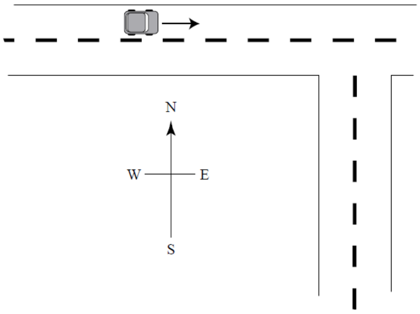
ROWING (2006;1)

Steve is in a rowing race. At the end of the race, Steve rows across a part of the river where there is a current flowing at a speed of 1.0 m s^{-1}. Steve points his boat at right angles to the river bank. His speed through the water is 3.0 m s^{-1}.

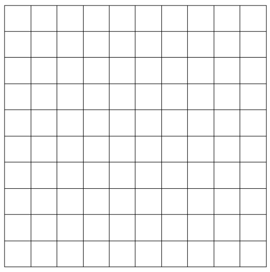


(g) Draw a velocity vector diagram showing the direction the boat travels. Use the diagram to calculate the boat's resultant speed. Calculate the angle between the river bank and the boat's velocity.

TRAVELLING BY CAR (2005;1)

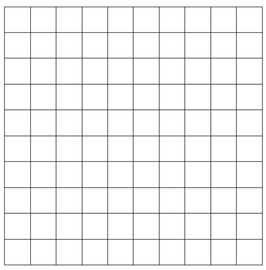


(f) Sometime later the car is travelling in an easterly direction with an initial velocity of 12 m s^{-1}. It makes a right-hand turn, and then travels south with a final velocity of 16 m s^{-1}.



(i) On the grid, using a scale of 1 square= 2 m s^{-1}, draw labelled vectors to represent the initial and final velocities of the car.

On the grid below, using a scale of 1 square = 2 m s^{-1}, draw a labelled vector diagram showing the change in velocity of the car.

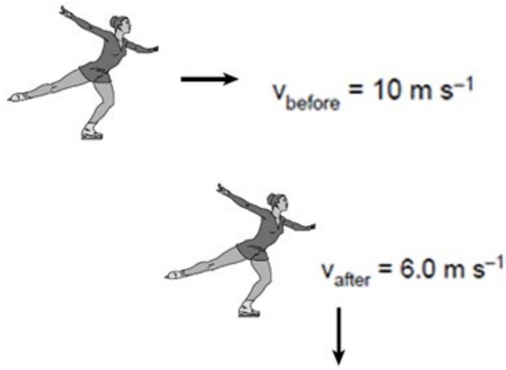


(ii) Calculate the size of the change in velocity of the car.

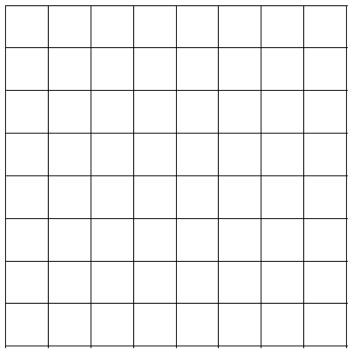
(iii) Calculate the direction of the change in velocity of the car.

SCHOOL TRIP - ICE SKATING (2004;4)

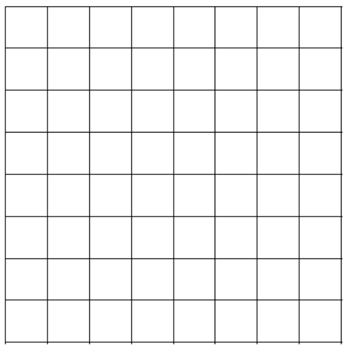
Ana is warming up on the ice. She skates in a straight line at a speed of 10 m s^{-1} and then she changes her speed to skate at a speed of 6.0 m s^{-1} at right angles to her original direction, as shown in the diagram.



(a) On the grid, and using the scale given, draw labelled arrows to show (i) Ana's initial velocity (ii) Ana's final velocity using a scale: 1 square = 2 m s^{-1}



(b) On the grid, draw a vector diagram to show the change in Ana's velocity. Scale: 1 square = 2 m s^{-1}



Use your vector diagram to calculate the size and the direction of the change in Ana's velocity. Show clearly on your diagram which angle you have calculated.