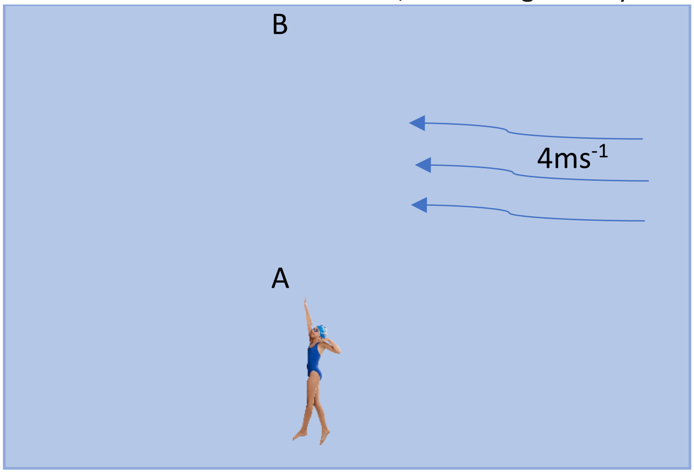
Our Dynamic Universe Practice Assessment

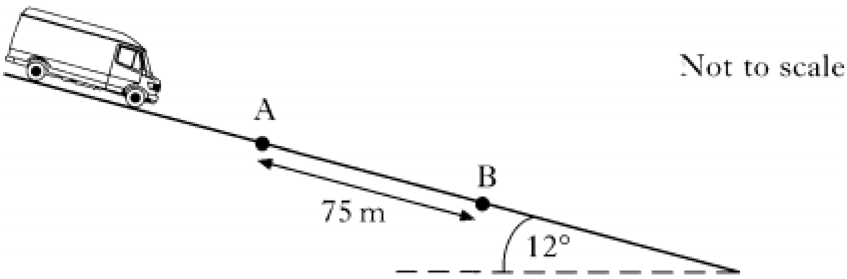
1 A swimmer wants to cross a river, swimming directly from point A to point B, as shown in the figure.



The swimmer aims to achieve an average **velocity** of $6ms^{-1}$. A current of $4ms^{-1}$ is acting East to West in the water. 3

By scale drawing or otherwise, find the magnitude and direction of the velocity required by the swimmer in order to achieve their target.

2 A van of mass 2600 kg moves down a slope which is inclined at 12° to the horizontal as shown.



(a) Calculate the component of the van's weight parallel to the slope. 2

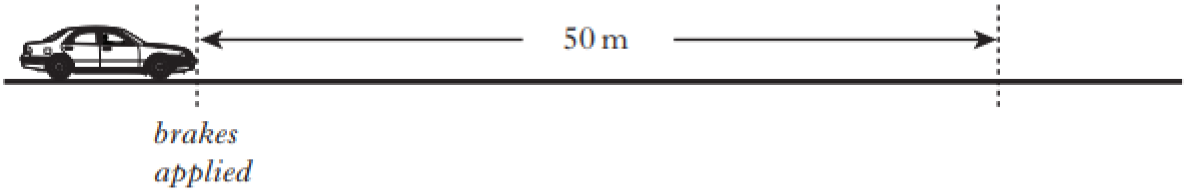
(b) A constant frictional force of 1400 N acts on the van as it moves down the slope.

Calculate the acceleration of the van. 3

(c) The speed of the van as it passes point **A** is $5{\cdot}0\,m\,s^{-1}$.
Point **B** is 75 m further down the slope.

Calculate the kinetic energy of the van at **B**. 4

3 A car is travelling along a straight, level road. The brakes are then applied and the car comes to rest in a distance of 50 m.



The work done in stopping the car is 75 kJ and the average external frictional force exerted on the car is 300 N.

The total mass of the car and driver is 1100 kg.

(a) Calculate the average force exerted by the brakes on the car. 3

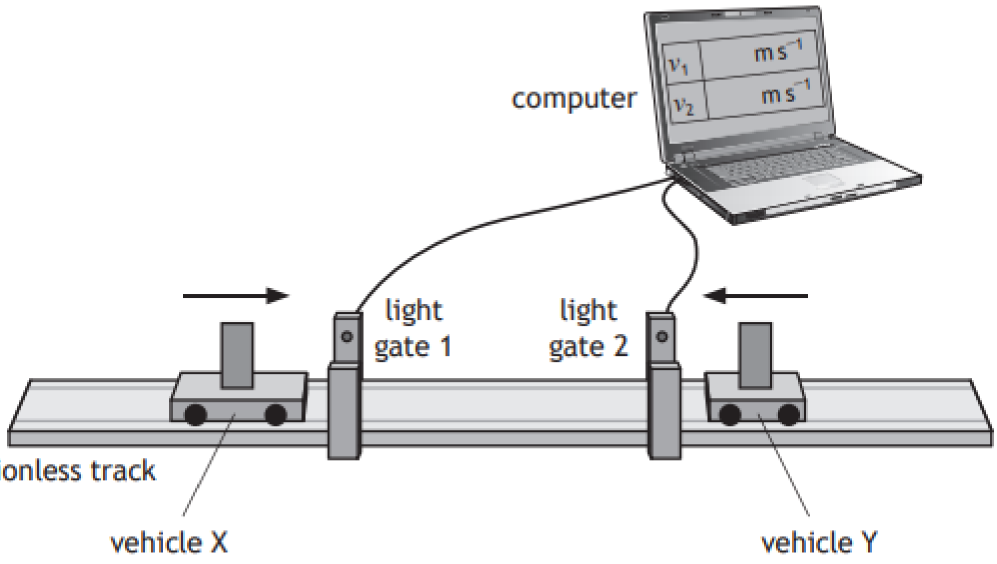
(b) A second car of smaller total mass is travelling at the same speed along the same road. Its brakes are applied and it stops in the same distance of 50 m.

The same average external frictional force is exerted on this car.

How does the value of the average braking force on this car compare to that of the original car?

You must justify your answer. 2

4 The following apparatus is set up to investigate the law of conservation of linear momentum.



In one experiment, vehicle X is travelling to the right along the track and vehicle Y is travelling to the left along the track.

The vehicles collide and stick together.

The computer displays the speeds of each vehicle before the collision.

The following data are recorded:

Mass of vehicle X = 0·85 kg

Mass of vehicle Y = 0·25 kg

Speed of vehicle X before the collision = 0·55 m s^{-1}

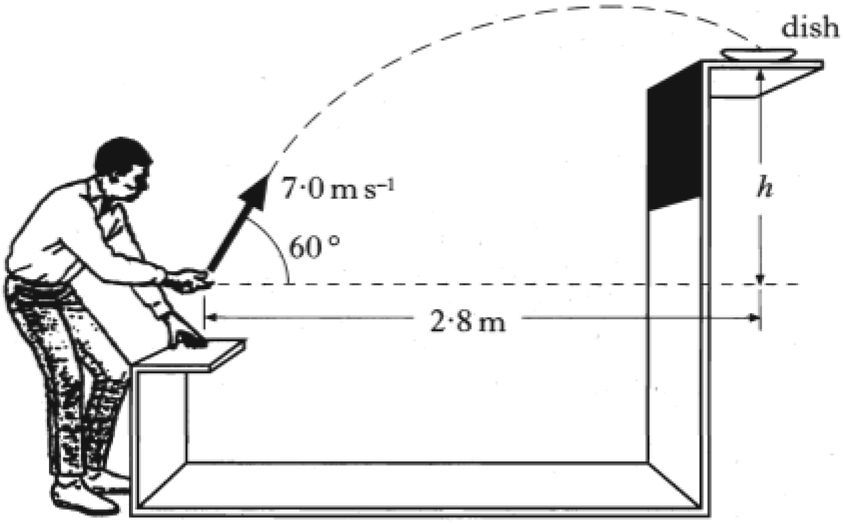
Speed of vehicle Y before the collision = 0·30 m s^{-1}

(a) State the law of conservation of linear momentum. 1

(b) Calculate the velocity of the vehicles immediately after the collision. 3

(c) Show by calculation that the collision is inelastic. 4

5 At a funfair, a prize is awarded if a coin is tossed into a small dish. The dish is mounted on a shelf above the ground as shown.



A contestant projects the coin with a speed of $7{\cdot}0\,m\,s^{-1}$ at an angle of $60°$ to the horizontal. When the coin leaves his hand, the **horizontal distance** between the coin and the dish is $2{\cdot}8\,m$. The coin lands in the dish.

The effect of air friction on the coin may be neglected.

(a) Calculate:

(i) the horizontal component of the initial velocity of the coin; 1

(ii) the vertical component of the initial velocity of the coin. 1

(b) Show that the time taken for the coin to reach the dish is $0{\cdot}8\,s$. 1

(c) What is the height, h, of the shelf above the point where the coin leaves the contestant's hand? 3

(d) How does the value of the kinetic energy of the coin when it enters the dish compare with the kinetic energy of the coin just as it leaves the contestant's hand?

Justify your answer. 2

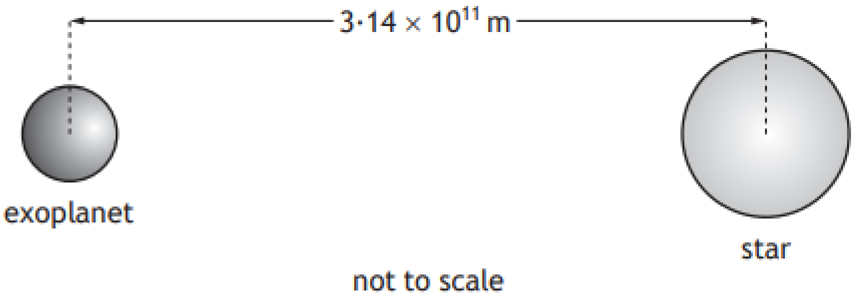
6 When viewed from the Earth, the continuous emission spectrum from the Sun has a number of dark lines. One of these lines is at a wavelength of 656 nm.

In the spectrum of light from a distant galaxy, the corresponding dark line is observed at 667 nm.

Calculate the redshift of the light from the distant galaxy. 3

7 Planets outside our solar system are called exoplanets.

An exoplanet of mass $5{\cdot}69 \times 10^{27}$ kg orbits a star of mass $3{\cdot}83 \times 10^{30}$ kg.



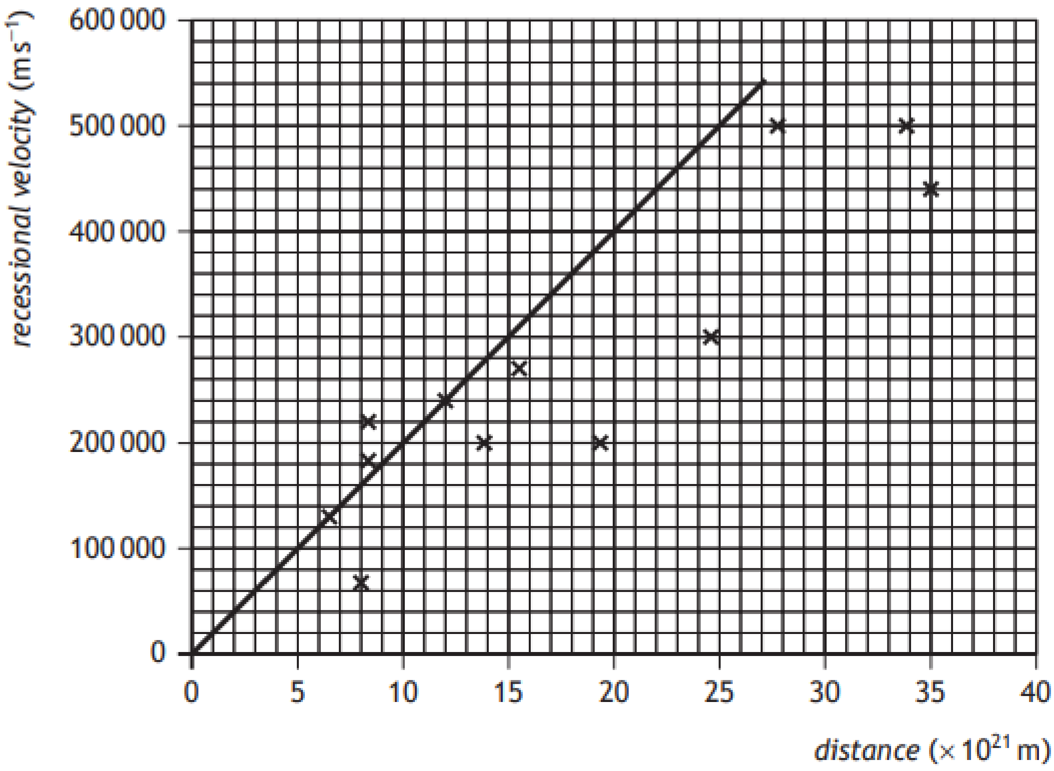
The distance between the exoplanet and the star is $3{\cdot}14 \times 10^{11}$ m.

Calculate the gravitational force between the star and the exoplanet. 3

8 Hubble's Law states that the universe is expanding. The expanding universe is one piece of evidence that supports the Big Bang theory.

(a) State one other piece of evidence that supports the Big Bang theory. 1

(b) A student plots some of the original data from the 1929 paper by Edwin Hubble and adds the line shown in order to determine a value for the Hubble constant H_0.



The student calculates the gradient of their line and obtains a value for the Hubble constant of $2{\cdot}0 \times 10^{-17}\,s^{-1}$.

The age of the universe can be calculated using the relationship

Calculate the age of the universe, in years, obtained when using the student's value for the Hubble constant. 2

TOTAL 44