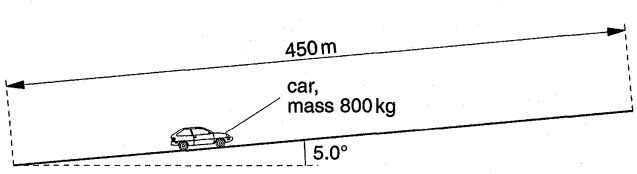
Kinematics

May 03

2 (a) **(i)** Define displacement.

(ii) Use your definition to explain how it is possible for a car to travel a certain distance and yet have zero displacement.[3]

(b) A car starts from rest and travels upwards along a straight road inclined at an angle of 5.0° to the horizontal , as illustrated in Fig. 2.1.



The length of the road is 450 m and the car has mass 800 kg. The speed of the car increases at a constant rate and is 28ms^{-1} at the top of the slope.

(i) Determine, for this car travelling up the slope, 1. its acceleration, acceleration = ... ms^{-2} [2]

2. the time taken to travel the length of the slope,
time taken = ... s [2]

3. the gain in kinetic energy,
gain in kinetic energy = ... J [2]

4. the gain in gravitational potential energy.
gain in potential energy = ... J [3]

(ii) Use your answers in (i) to determine the useful output power of the car. power= ..... W [3]

(iii) Suggest one reason why the actual power output of the car engine is greater than that calculated in **(ii).** [2]

Nov 03

1 (a) One of the equations of motion may be written as

$$v^2 = u^2 + 2as.$$

(i) Name the quantity represented by the symbol *a.*

(ii) The quantity represented by the symbol a may be either positive or negative. State the significance of a negative value.

(b) A student investigates the motion of a small polystyrene sphere as it falls from rest alongside a vertical scale marked in centimeters. To do this, a number of flash photographs of the sphere are taken at 0.1 s intervals, as shown in Fig. 1.1.

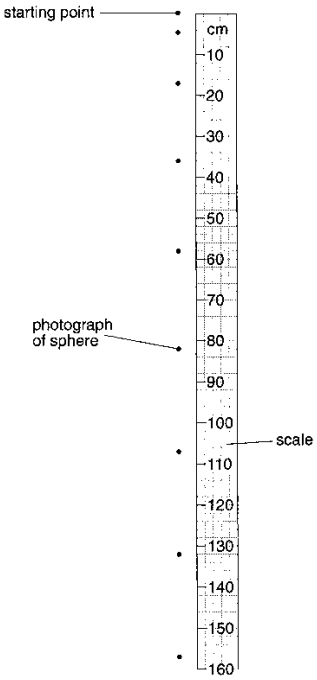


Fig. 1.1

The first photograph is taken at time f = 0.

By reference to Fig. 1.1,

(i) brietly explain how it can be deduced that the sphere reaches a constant speed,

(ii) determine the distance that the sphere has fallen from rest during a time of 0.7s, distance =..... cm

1.1s, distance =..... cm

(c) The student repeats the experiment with a lead sphere that falls with constant acceleration and does not reach a constant speed.

Determine the number of flash photographs that will be observed against the 160cm scale.

Include in your answer the photograph obtained at time t = 0.

Nov 04

3 A girl stands at the top of a cliff and throws a ball vertically upwards with a speed of 12ms^{-1}, as illustrated in Fig. 3.1.

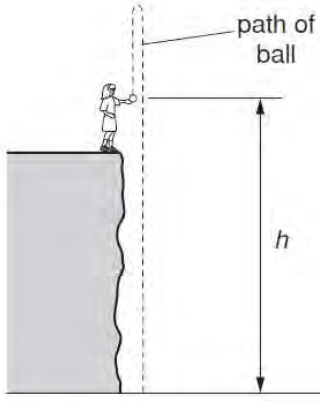


Fig. 3.1

At the time that the girl throws the ball, her hand is a height *h* above the horizontal ground at the base of the cliff.

The variation with time *t* of the speed *v* of the ball is shown in Fig. 3.2.

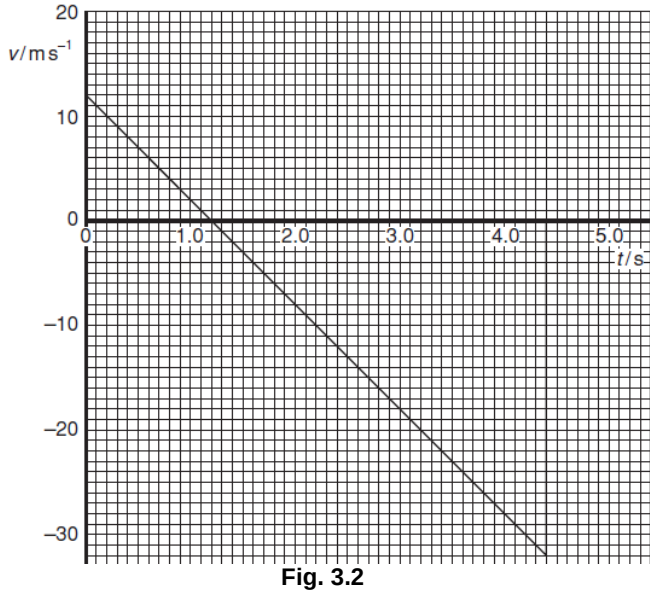


Fig. 3.2

Speeds in the upward direction are shown as being positive. Speeds in the downward direction are negative.

(a) State the feature of Fig. 3.2 that shows that the acceleration is constant. [1]

(b) Use Fig. 3.2 to determine the time at which the ball

(i) reaches maximum height, time = ……. s

(ii) hits the ground at the base of the cliff. time = ……. s [2]

(c) Determine the maximum height above the base of the cliff to which the ball rises. height = ……. ……. m [3]

(d) The ball has mass 250 g. Calculate the magnitude of the change in momentum of the ball between the time that it leaves the girl's hand to time *t* = 4.0s. change = …… Ns [3]

(e) (i) State the principle of conservation of momentum. [2]

(ii) Comment on your answer to **(d)** by reference to this principle. [3]

Nov 05

3 A stone on a string is made to travel along a horizontal circular path, as shown in Fig. 3.1.

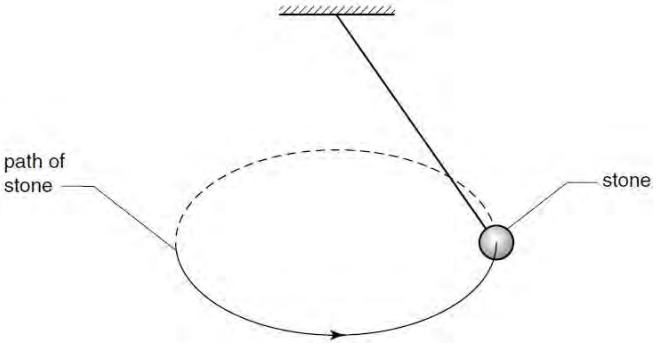


Fig. 3.1

The stone has a constant speed.
(a) Define *acceleration*. [1]
(b) Use your definition to explain whether the stone is accelerating. [2]

June 06
1. A spherical ball of radius *r* experiences a resistive force *F* due to the air as it moves through the air at speed *v*. The resistive force *F* is given by the expression

$$F = crv,$$

where *c* is a constant.
(c) The ball is dropped from rest through a height of 4.5m.
(i) Assuming air resistance to be negligible, calculate the final speed of the ball. speed = ……. ms^{-1} [2]
(ii) The ball has mass 15 g and radius 1.2 cm.
The numerical value of the constant *c* in the equation in **(b)** is equal to 3.2×10^{-4} when measured using the SI system of units. Show quantitatively whether the assumption made in **(i)** is justified.

Nov 06
2 A student investigates the speed of a trolley as it rolls down a slope, as illustrated in Fig. 2.1.

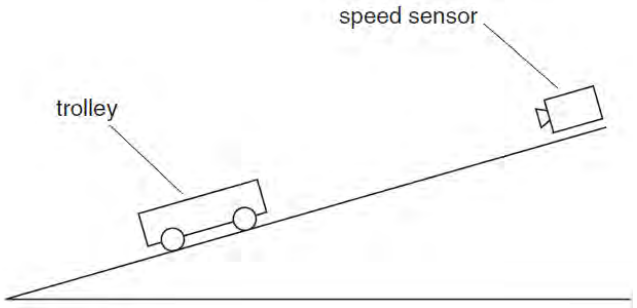


Fig. 2.1

The speed *v* of the trolley is measured using a speed sensor for different values of the time *t*
that the trolley has moved from rest down the slope.
Fig. 2.2 shows the variation with *t* of *v*.

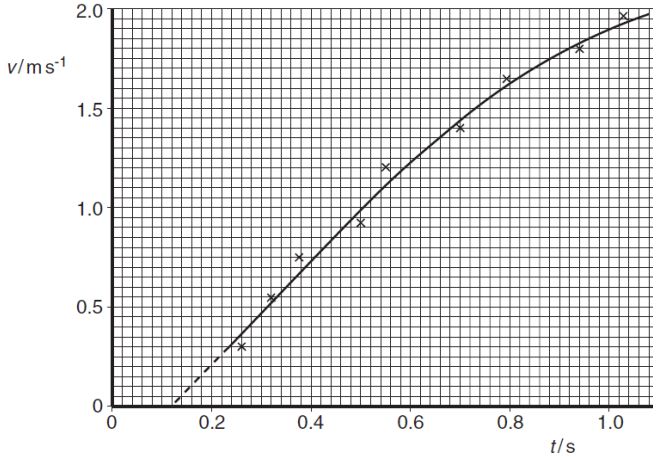


Fig. 2.2

(a) Use Fig. 2.2 to determine the acceleration of the trolley at the point on the graph where *t* = 0.80 s. acceleration = ……. ms^{-2} [4]
(b) (i) State whether the acceleration is increasing or decreasing for values of *t* greater than 0.6 s. Justify your answer by reference to Fig. 2.2. [2]
(ii) Suggest an explanation for this change in acceleration. [1]

May 07
2
(b) Two flat parallel metal plates, each of length 12.0 cm, are separated by a distance of 1.5 cm, as shown in Fig. 2.1.

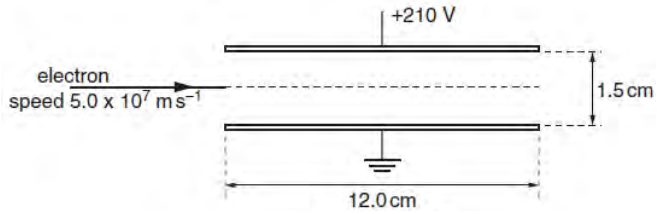


Fig. 2.1

The space between the plates is a vacuum.
The potential difference between the plates is 210 V. The electric field may be assumed to be uniform in the region between the plates and zero outside this region.
Calculate the magnitude of the electric field strength between the plates. field strength = ...N C^{-1} [1]
(c) An electron initially travels parallel to the plates along a line mid-way between the plates, as shown in Fig. 2.1. The speed of the electron is 5.0×10^7 m s^{-1}.
For the electron between the plates,
(i) determine the magnitude and direction of its acceleration,
acceleration = ...m s^{-2}
direction .....[4]
(ii) calculate the time for the electron to travel a horizontal distance equal to the length of the plates.
time = ...s [1]
(d) Use your answers in **(c)** to determine whether the electron will hit one of the plates or emerge from between the plates.

Nov 07
2 A girl G is riding a bicycle at a constant velocity of 3.5 ms^{-1}. At time *t* = 0, she passes a boy B sitting on a bicycle that is stationary, as illustrated in Fig. 2.1.

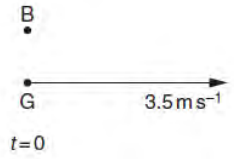


Fig. 2.1

At time *t* = 0, the boy sets off to catch up with the girl. He accelerates uniformly from time *t* = 0
until he reaches a speed of 5.6 m s–1 in a time of 5.0 s. He then continues at a constant speed
of 5.6 m s–1. At time *t* = *T*, the boy catches up with the girl. *T* is measured in seconds.
(a) State, in terms of *T*, the distance moved by the girl before the boy catches up with her. distance = ... m [1]
(b) For the boy, determine
(i) the distance moved during his acceleration,
distance = ... m [2]
(ii) the distance moved during the time that he is moving at constant speed. Give your answer in terms of *T*.
distance = ... m [1]
(c) Use your answers in **(a)** and **(b)** to determine the time *T* taken for the boy to catch up with the girl.
T = ... s [2]
(d) The boy and the bicycle have a combined mass of 67 kg.
(i) Calculate the force required to cause the acceleration of the boy. force = ... N [3]
(ii) At a speed of 4.5 m s^{-1}, the total resistive force acting on the boy and bicycle is 23 N. Determine the output power of the boy's legs at this speed. power = ... W [2]
May 08

3 A shopping trolley and its contents have a total mass of 42 kg. The trolley is being pushed along a horizontal surface at a speed of 1.2 m s^{-1}. When the trolley is released, it travels a distance of 1.9 m before coming to rest.
(a) Assuming that the total force opposing the motion of the trolley is constant,
(i) calculate the deceleration of the trolley,
deceleration = ... m s^{-2} [2]
(ii) show that the total force opposing the motion of the trolley is 16 N. [1]
(b) Using the answer in **(a)(ii)**, calculate the power required to overcome the total force opposing the motion of the trolley at a speed of 1.2 m s^{-1}. power = ... W [2]
(c) The trolley now moves down a straight slope that is inclined at an angle of 2.8° to the horizontal, as shown in Fig. 3.1.

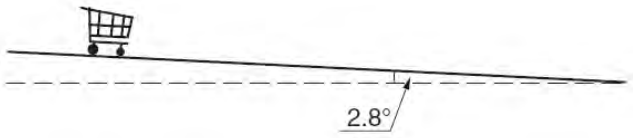


Fig. 3.1

The constant force that opposes the motion of the trolley is 16 N. Calculate, for the trolley moving down the slope,
(i) the component down the slope of the trolley's weight,
component of weight = ... N [2]
(ii) the time for the trolley to travel from rest a distance of 3.5 m along the length of the slope. time = ... s [4]
(d) Use your answer to **(c)(ii)** to explain why, for safety reasons, the slope is not made any steeper. [1]

Nov 08
2 A car is travelling along a straight road at speed *v*. A hazard suddenly appears in front of the car. In the time interval between the hazard appearing and the brakes on the car coming into operation, the car moves forward a distance of 29.3 m. With the brakes applied, the front wheels of the car leave skid marks on the road that are 12.8 m long, as illustrated in Fig. 2.1.

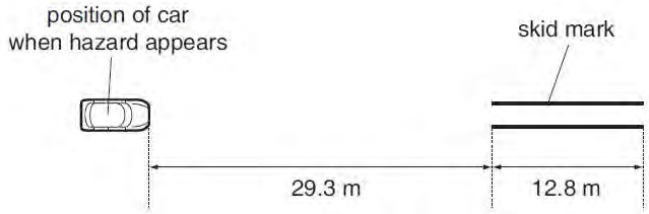


Fig. 2.1

It is estimated that, during the skid, the magnitude of the deceleration of the car is 0.85 *g*, where *g* is the acceleration of free fall.
(a) Determine
(i) the speed *v* of the car before the brakes are applied,
v = ... m s^{-1} [2]
(ii) the time interval between the hazard appearing and the brakes being applied. time = ... s [2]
(b) The legal speed limit on the road is 60 km per hour.
Use both of your answers in **(a)** to comment on the standard of the driving of the car. [3]

June 09
6 Two vertical parallel metal plates are situated 2.50 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown in Fig. 6.1.

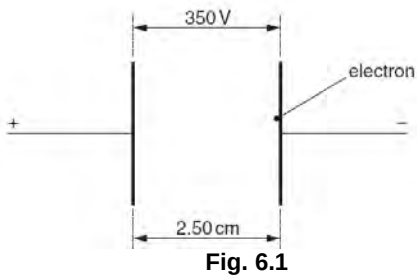


Fig. 6.1

An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.
(b) the force on the electron due to the electric field is 2.24×10^{-15} N. The electron accelerates horizontally across the space between the plates. Determine
(i) the horizontal acceleration of the electron,
acceleration = ... m s^{-2} [2]
(ii) the time to travel the horizontal distance of 2.50 cm between the plates. time = ... s [2]
(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**. [2]