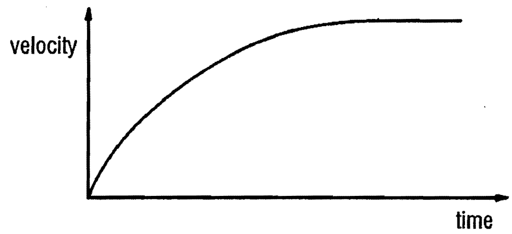
TOPIC 2 Kinematics

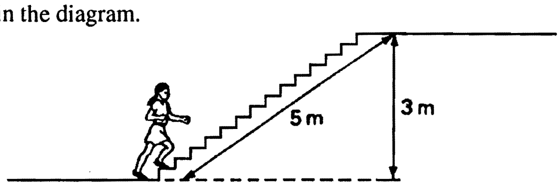
1 The graph shows how the velocity of a car changes with time.



Which of the following can be deduced from the graph?

A The car decelerates until it stops.
B The car first decelerates and then moves with a steady velocity.
C The car accelerates uniformly.
D The car accelerates at an increasing rate.
E The car first accelerates and then moves with a steady velocity. J90/I/2

2 A girl weighing 400 N takes 4 s to run up the stairs shown in the diagram.



What is her average speed?

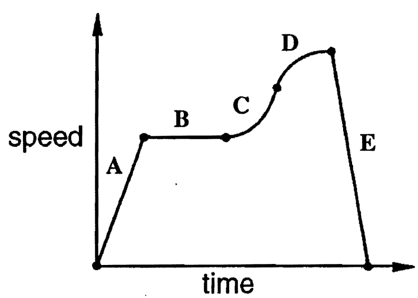
A 0.75 m/s **D** 1.33 m/s
B 0.8 m/s **E** 12 m/s
C 1.25 m/s J90/I/7

3 A cyclist riding at a speed of 5 m/s braked with uniform acceleration and stopped in 3 m.

How long did she take to stop?

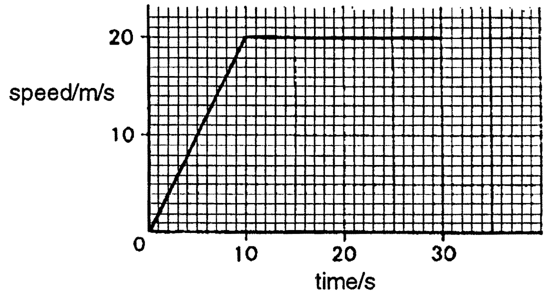
A 0.6 s **D** 3.0 s
B 1.2 s **E** 7.5 s
C 1.33 s N90/I/2

4 The graph shows how the speed of an object changes with time.



Which section of the graph shows the object moving with an increasing acceleration? N90/I/3

5 The graph shows part of a car journey.

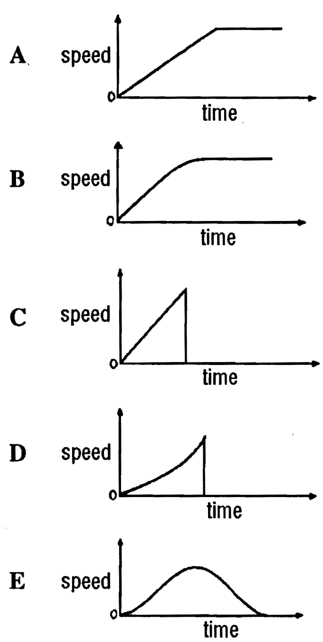


What distance is travelled by the car in the first ten seconds?

A 10 m
B 100 m
C 150 m
D 200 m
E 400 m J91/I/2

6 A small stone is dropped from the top of a ladder and falls to the ground.

Which speed/time graph shows how the stone's speed varies?



J91/I/3

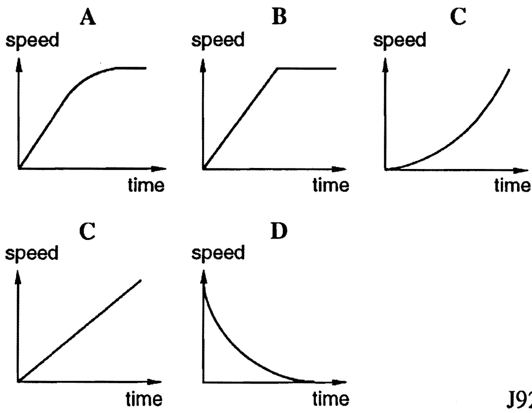
7 During a thunderstorm, an observer sees a lightning flash. 6 seconds later he hears the thunder. The speed of sound is 330 m/s.

Approximately how far away is the observer from the lightning?

A $\frac{1}{20}$ km **D** 2 km
B $\frac{1}{3}$ km **E** 30 km
C $\frac{1}{2}$ km N91/I/3

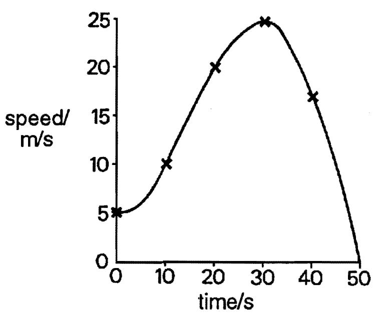
8 A body is allowed to fall from rest through air. It reaches its terminal velocity.

Which graph shows how the speed of the body changes with time?



J92/I/2

9 Below is a speed-time graph for a car.



What is the acceleration of the car when the time is 30 s?

A $0\ m/s^2$

B $\frac{25-5}{30}\ m/s^2$

C $\frac{25}{30}\ m/s^2$

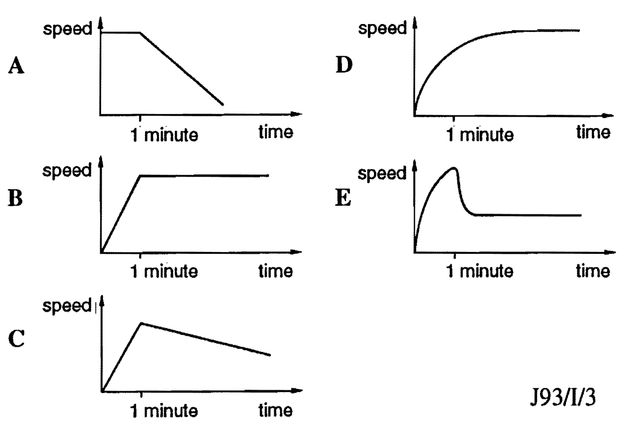
D $20\ m/s^2$

E $25\ m/s^2$

N92/I/2

10 After a parachutist has been falling for 1 minute, his parachute opens.

Which graph best shows how his speed varies with time?



J93/I/3

11 An Eskimo is pulling a sledge across level snow. The sledge has a mass of 25 kg. The Eskimo pulls with a horizontal force of 60 N and the constant force of friction is 20 N.

What is the acceleration of the sledge?

A $0.080\ m/s^2$

B $0.625\ m/s^2$

C $1.6\ m/s^2$

D $1.8\ m/s^2$

E $3.2\ m/s^2$

J93/I/7

12 Sand was dropped from a stationary hot-air balloon at a height of 2000 metres.

Which statement best describes the fall of the sand to the ground?

A The speed increases uniformly all the way.

B The speed increases and then remains constant.

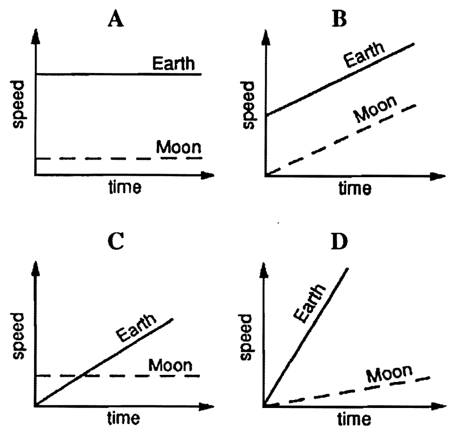
C The speed remains constant all the way.

D The speed decreases and then remains constant.

J94/I/3

13 When someone on Earth drops a rock, it accelerates at about $10\ m/s^2$. When a rock is dropped on the Moon, the rock accelerates at about $1.6\ m/s^2$.

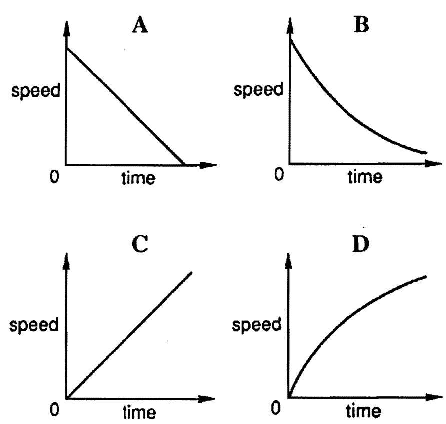
Which diagram shows the speed-time graphs for rocks dropped on the Earth and on the Moon?



N94/I/3

14 A car accelerates from rest. The acceleration gradually decreases.

Which graph shows how the speed of the car changes?



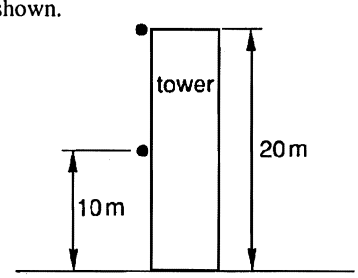
J95/I/2

15 A body falls from rest through air until it reaches its terminal velocity.

How can the acceleration of the body during the fall be described?

A constant at 0 m/s^2
B constant at 10 m/s^2
C decreases from 10 m/s^2 to 0 m/s^2
D increases from 0 m/s^2 to 10 m/s^2 J95/I/3

16 Two similar cricket balls are released from a 20 m tower at the same time. One falls from the top, the other from half way up, as shown.



Which quantity is the same for both balls?

A acceleration
B final speed
C increase in velocity
D time of travel N95/I/2

17 A ball falls freely (with no air resistance) near the surface of the Earth.

Which quantity remains constant?

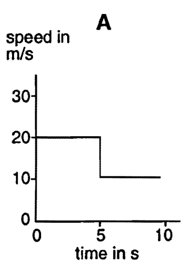
A acceleration
B distance travelled in 1 s
C speed
D velocity J96/I/3, June 2000/I/2

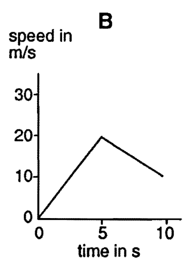
18 What **must** be changing when a body is accelerating uniformly?

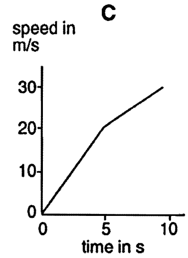
A the force acting on the body
B the mass of the body
C the speed of the body
D the velocity of the body N96/I/2

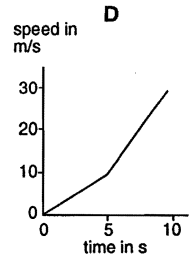
19 A skier is travelling downhill. The acceleration on hard snow is 4 m/s^2 and on soft snow is 2 m/s^2.

Which graph shows the motion of the skier when moving from hard snow to soft snow?







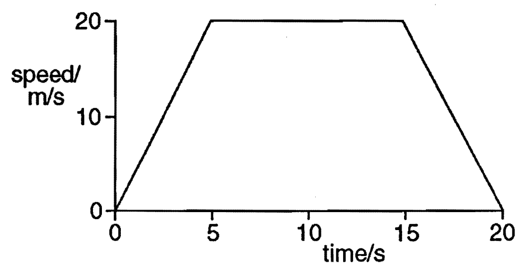


J97/I/3

20 Acceleration can be calculated using

A average speed × time.
B change in velocity / time.
C distance / time.
D force × mass. N97/1/3

21 The speed of a body during 20 s of motion is represented by the speed-time graph shown.



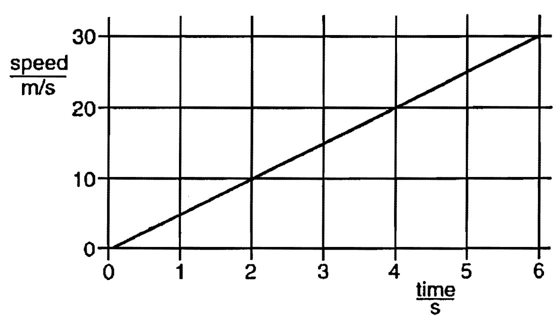
Which distance does the body travel during this motion?

A 200 m **C** 300 m
B 250 m **D** 400 m N98/I/2

22 Why does an object falling in the Earth's gravitational field reach a steady velocity?

A Air resistance increases with increase of velocity.
B The Earth's gravitational field decreases as the object falls.
C The mass of the object remains constant.
D The weight of the object increases as it falls. N99/I/2

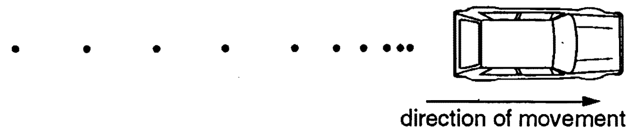
23 A car starts from rest and is uniformly accelerated to a speed of 30 m/s in 6 s.



What is the distance travelled by the car?

A 5 m **C** 90 m
B 30 m **D** 180 m N99/I/3

24 Oil drips at a constant rate from a moving car. The diagram shows the pattern of the drips on a road.



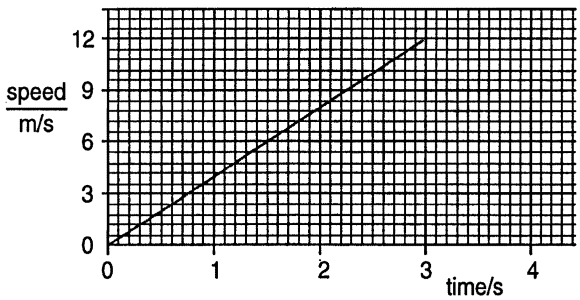
Which statement describes the motion of the car?

A It accelerated and then moved at a steady speed.
B It accelerated and then slowed down.
C It moved at a steady speed and then slowed down.
D It moved at a steady speed and then accelerated.

J2000/I/3

25 The graph shows the speed of a car as it moves from rest.

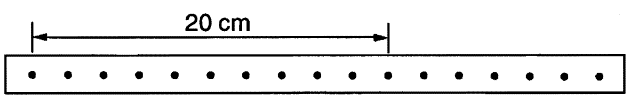
What is the average speed of the car during the first 3 s?



A 4 m/s **C** 18 m/s
B 6 m/s **D** 36 m/s

N2000/I/2

26 The diagram shows a strip of paper tape that has been pulled under a vibrating arm by an object moving at constant speed. The arm is vibrating regularly, making 50 dots per second.

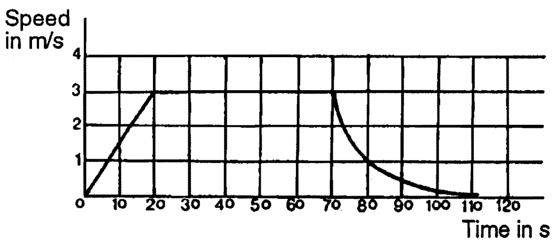


What was the speed of the object?

A 2.0 cm/s **C** 100 cm/s
B 5.0 cm/s **D** 200 cm/s

N2000/I/3

27 The diagram shows the speed-time graph for the motion of a body. Determine the distance the body travels



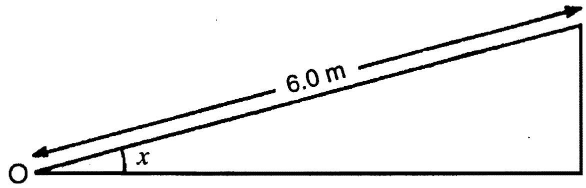
(a) during the initial acceleration,

(b) When travelling at constant speed.

Estimate the distance the body travels during the 40 s which it takes to come to rest.

J79/I/2

28 A ramp is inclined to the horizontal at a fixed angle x and is 6.0 m long, as shown in the diagram.



A ball was placed on the ramp, a measured distance d from the point O and allowed to roll, without slipping, from rest to the point O. The time taken, t, was recorded. The experiment was repeated for a number of different distances d, the corresponding times t were found and values of t^2 calculated. The results are recorded in the table below.

d/m	0.90	1.70	2.80	3.90	4.80
t^2/s^2	0.86	1.62	2.67	3.71	4.57

Plot a graph of d (along the y-axis) against t^2 (along the x-axis), making sure that the y-axis covers the range of values of d from 0 to 7 m and that the x-axis covers the range of values of t^2 from 0 to 6 s^2.

Determine b, the gradient of the graph, showing clearly how you obtain the value. The acceleration of the ball down the slope is equal to $2b$; state your value for this acceleration.

What would be the effect on the value of the acceleration of increasing the angle x and repeating the experiment'?

By suitably extending the graph, find the time it would take the ball to roll down the whole 6 m length of the ramp.

Suggest a method of measuring the distance, d, rolled down the slope by the ball in this experiment in such a way as to obtain the greatest accuracy.

J80/I/II/1A

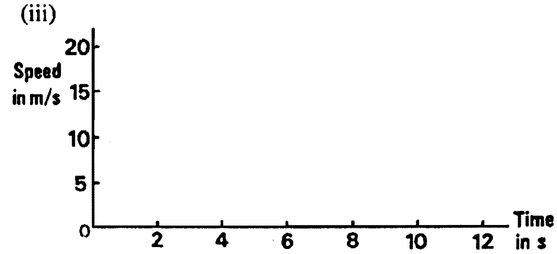
29 *(a)* A flat puck lies at rest on a flat, horizontal surface. The contact between the puck and the surface may be regarded as frictionless.

A steady horizontal force F, of magnitude 0.50 N is applied to the puck, the mass of which is 0. 10 kg. The force acts on the puck for a time of 3.0 s and then ceases to act.

(i) Determine the acceleration of the puck while the force is acting on it.

(ii) Determine the speed of the puck at the end of the 3. 0 s.

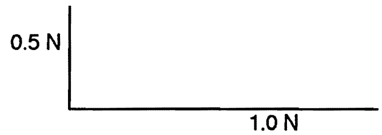
(iii)



Draw, using the axes shown, a speed-time graph for the motion of the puck, starting at the instant the force is first applied and ending 12.0 s later.

From the graph, or otherwise, find the distance the puck has travelled in the 12 s.

(b) The diagram below illustrates a situation in which two horizontal forces, of magnitude 0.5 N and 1.0 N, act, at a point, in directions at right angles to each other. The diagram is drawn to scale; 100 mm represents 1.0 N.

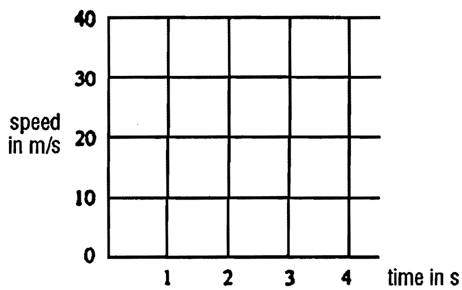


Complete the scale drawing to determine the magnitude of the *resultant* of the two forces.

N80/II/1

30 *(a)* A lead mass is held stationary at a point X above the Earth's surface and is then allowed to fall freely. The height of X is such that the mass takes more than 3 s to reach the ground.

Plot a graph showing the speed of the falling mass against time for the first 3.0 s of the motion. Assume that air resistance can be neglected and that the acceleration of free fall is 10 m/s^2.



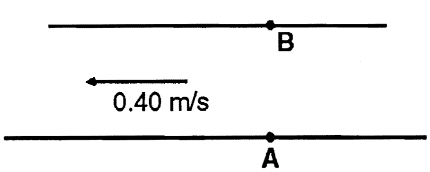
(b) When the lead mass is released from a different point P, it strikes a metal plate directly below P 1.8 s after starting to fall. Using your graph or otherwise, find the height of the point P above the metal plate.

(c) Why would it be unsatisfactory to use a stopwatch to determine this time interval?

(d) Draw a labelled diagram of an experimental arrangement which is satisfactory for measuring this time interval.

N81/II/2

31 A river that is 40 m wide flows at 0.4 m/s in the direction shown. A man sets out from A in a rowing boat heading in the direction AB. His speed through the water is 0.80 m/s.



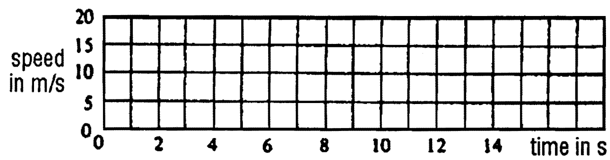
Determine

(i) the time taken to reach the far bank,

(ii) the distance from B at which he reaches the bank.

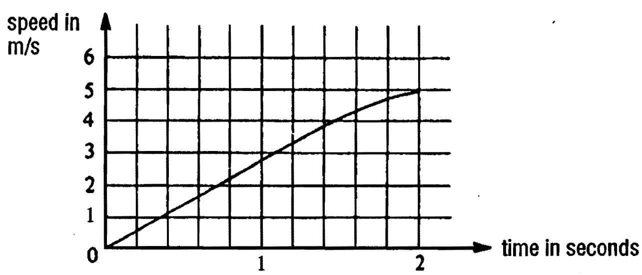
J82/I/1

32 A car travels at a constant speed of 15 m/s for 8.0 s and is then brought to rest in 4.0 s by a constant braking force. On the axes below, draw a graph to show how the speed of the car varies with time. Determine the total distance travelled by the car in this period of 12 s.



J82/I/4

33 A driver accelerates his car from rest. The speed-time graph for the first 2.0 s of the motion is shown in the diagram. Initially, the acceleration is constant but soon decreases.



(a) Indicate on the graph the limit of the period of uniform acceleration.

(b) From the graph,

(i) find the magnitude of the initial acceleration,

(ii) estimate the distance travelled by the car in the first 2.0 s of its motion,

(iii) calculate the work done by the force driving the car forwards in the first 2.0 s of the motion, given that this force is constant at 3000 N.

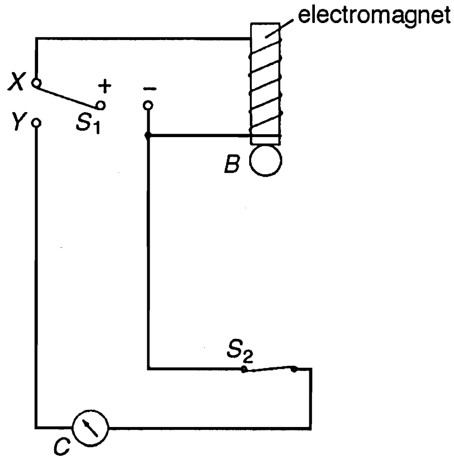
(c) Suggest a reason why the acceleration is not maintained at its initial magnitude even though the driving force is constant.

J83/II/1

34 A car accelerates uniformly from rest to a speed of 15.0 m/s in 10.0 s: after travelling at this constant speed for 16.0 s, it is brought to rest with uniform retardation in 6.0 s. Find the total distance the car travels in this motion.

N84/I/1

35 The diagram shows apparatus which was used to investigate the fall of a small soft-iron ball B, initially held by an electromagnet. When the switch S_1 is changed quickly, from contact X to contact Y, the ball falls and an electronic clock, C, is started. When the ball hits switch S_2 the timing circuit is broken and the clock stops.



The vertical distance x, through which the ball falls before opening S_2, is measured and t, the time of fall noted.

(a) On the diagram mark x, the vertical distance through which B falls.

(b) The experiment was repeated for five different values of x. For each value of x three trials were conducted and the average time of fall, t_a, determined.

Construct a table in which the observations could be recorded and t_a displayed.

(c) How would you measure x, to the nearest mm, when it is in the range 0.500 m to 0.900 m? J85/I/II/2

36 Explain the meanings of the terms *velocity* and *acceleration* of a moving body. Draw graphs of velocity against time for the first 5.0 s of the motion of:

(a) a body A moving with a uniform velocity of 4.5 m/s

(b) a body B which has an initial velocity 4.0 m/s and a uniform acceleration, in the same direction, of 2.0 m/s^2.

Using your graph, or otherwise, determine the distance travelled by B in the 5.0 s.

Describe a laboratory experiment to measure the acceleration of a moving body. Draw a labelled diagram of the arrangement of apparatus, state what readings are taken and show how the acceleration is calculated from the observations.

In an experiment using failing bodies, a student measured the acceleration of free fall of a steel ball using a vertical distance of 2.0 m. He repeated his experiment using a distance of 20.0 m to see if the acceleration remained constant.

What do you think the result of his experiment would be?

Give a reason for your answer. J85/II/7

37 *(a)* State what is meant by *acceleration*.

Fig. 1 illustrates a slide such as may be found in a children's playroom.

Describe clearly how you would measure the acceleration of a metal block sliding down the section PQ.

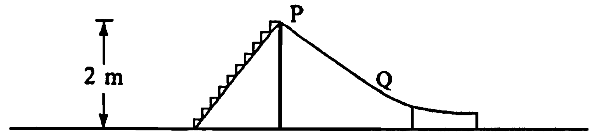


Fig. 1 N85/II/1*(a)*

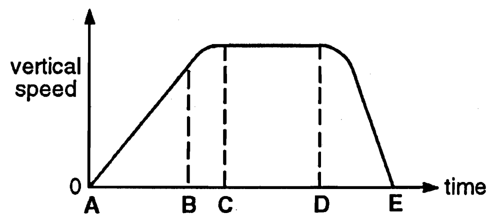
38 A body is accelerated uniformly from rest and in the first 8.0 s of its motion it travels 20 m. Calculate

(i) the average speed for this period of 8 S,

(ii) the speed at the end of this period,

(iii) the acceleration. N87/I/1

39 *(a)* The motion of a hot air balloon during an interval A to E after it began to rise from the ground is illustrated by the graph below.



Describe the motion of the balloon

(i) during the interval A to B,

(ii) during the interval C to D,

(iii) at time E. [4]

(b) When the balloon was stationary at a height of 25 m above the ground, a metal sphere was dropped. The sphere accelerated uniformly as it fell to the ground. An observer, noted that it took 2.0 s for the sphere to reach the ground.

Calculate values for

(i) the average speed of the sphere as it fell,

(ii) the maximum speed of the sphere,

(iii) the acceleration of the sphere as it fell.

In the light of your value for the acceleration, suggest in what way the original observations may have been faulty. [6] J88/II/1

40 Fig. 2 shows the speed-time graph for a child on a swing.

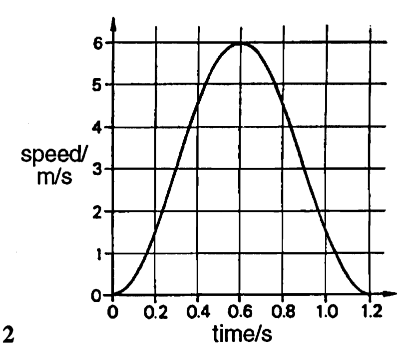


Fig. 2

(a) Write down:

(i) the maximum speed,

(ii) the time at which the maximum speed occurs. [1]

(b) (i) On the graph, mark with a cross one point at which the magnitude of the acceleration of the child is a maximum. Label this point 'M'.

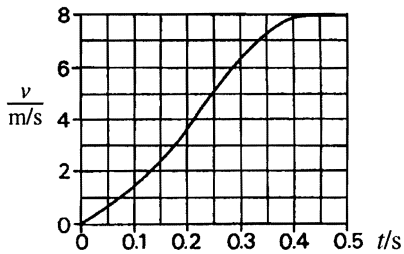
(ii) Mark one point at which the acceleration is zero. Label this point 'Z'. [2]

(c) Estimate the distance travelled by the child in 1.2 s. [2]

(d) Describe briefly the changes in acceleration during the period shown on the graph. [2]

N90/II/1

41 The graph shows the variation of speed with time of a runner over the first 0.5 s of a particular run.



For this part of the run,

(a) determine the maximum speed of the runner,

(b) describe briefly how the *acceleration* of the runner varied,

(c) estimate the distance travelled by the runner. [6]

N91/II/1

42 Students, investigating motion down an inclined plane, measure the speed of a steel ball at one second intervals after the ball starts to roll from rest down one such plane:

time in s	0.00	1.00	2.00	3.00
speed in m/s	0.00	0.60	1.20	1.80

(a) Calculate the average acceleration over the first 3.00 seconds. [2]

(b) Calculate the average speed over the first 3.00 seconds. [2]

(c) What was the distance travelled by the ball in the first 3.00 seconds? [1]

(d) How do the numbers in the table show that the acceleration was constant? [1]

J92/II/3

43 A car of length 6.0 m accelerates from rest along a straight level road as shown in **Fig. 3.**

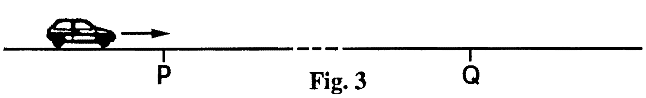


Fig. 3

The car takes 2.0 s to pass the point **P.**

10.0 s later the car has just passed the point **Q.**

The car takes 0.40 s to pass point **Q.**

(a) Calculate

(i) the average speed of the car as it passes **P,**

Speed at **P** = ...

(ii) the average speed of the car as it passes **Q,**

Speed at **Q** = ...

(iii) the average acceleration of the car between **P** and **Q.**

Acceleration = ... [5]

(b) (i) Estimate the distance between **P** and **Q.**

Distance between **P** and **Q** = ...

(ii) What assumption did you make when you estimated the distance between **P** and **Q**? [3]

J93/II/1

44 Figure 4 is a graph showing the variation of the speed v of an object with time t, as the object falls through the air.

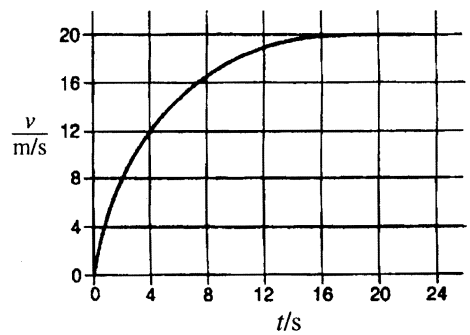


Fig. 4

(a) Write down the speed of the object when its acceleration is

(i) at its maximum value, Speed = ...

(ii) at its minimum value. Speed = ... [2]

(b) Write down the minimum value of the acceleration of the object. [1]

(c) Estimate the distance travelled by the object in the first 2.0 seconds. Show your working clearly [3]

N93/II/1

45 Figure 5.2 shows the variation of speed v with time t of a child sitting on the end of a see-saw (see Fig. 5.1), for one complete up-and-down motion.

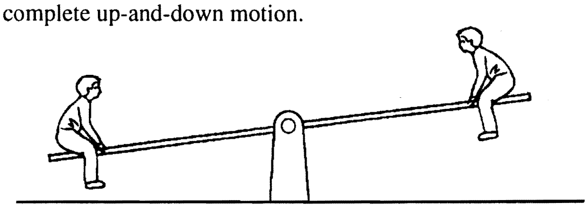


Fig. 5.1

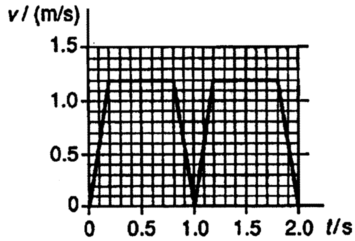


Fig. 5.2

(a) What is the maximum speed of the child?

Maximum speed = ... [1]

(b) Estimate the distance moved by the child during the first 1.0 s.

Distance moved = ... [4]

J94/II/1

46 A woodworking machine is turned using a belt-drive from an electric motor. Figure 6 shows the motor pulley, the belt and the machine pulley. The belt does not slip on either pulley.

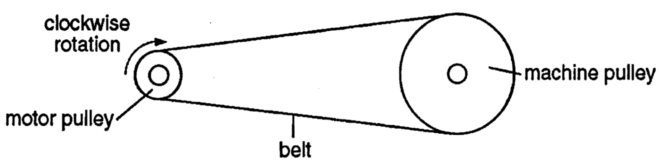


Fig. 6

(a) The diameter of the motor pulley is 12.0 cm; the diameter of the machine pulley is 30.0 cm. The motor pulley rotates in a clockwise direction at a constant rate of 30 revolutions per second.

Calculate

(i) the circumference of the motor pulley,

(ii) the speed of the belt in m/s.

Circumference of motor pulley = ...

Speed of belt = ... [4]

(b) (i) State the direction of rotation of the machine pulley.

Direction of rotation of machine pulley ....

(ii) State and explain whether the machine pulley will rotate more quickly or less quickly than the motor pulley. J95/II/1

47

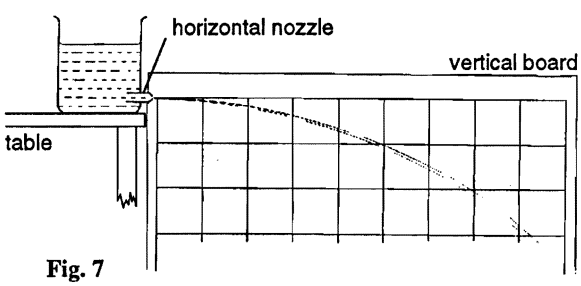


Fig. 7

Figure 7 shows an experimental arrangement for determining the speed of the jet of water emitted by a horizontal nozzle. A large vertical sheet of graph paper is placed behind the jet.

The horizontal displacement x and the vertical displacement y of a number of points along the jet are measured.

(a) Explain why the path of the water jet

(i) is horizontal close to the nozzle,

(ii) gets more nearly vertical as it moves away from the nozzle.

(The horizontal motion of a body is not affected by its vertical motion.) [4]

(b) The Table gives one set of corresponding values of x and y.

x/m	0	0.400	0.500	0.600	0.700	0.800
y/m	0	0.120	0.200	0.300	0.390	0.520

Theory suggests that y and x are related by the equation

$$y = kx^2,$$

where k is a constant.

(i) Draw up a table showing corresponding values of x^2 and y.

(ii) Plot a graph of y (y-axis) against x^2 (x-axis). [5]

(c) Theory also suggests that k, the gradient of the graph, is given by

$$k = \frac{g}{2u^2},$$

where g = the acceleration of free fall and u = the horizontal speed of the jet.

Determine

(i) the gradient of your graph,

(ii) a value for u, taking the value of g to be 10 m/s^2. [6]

J95/II/9

48 Figure 8 shows the variation of speed v with time t at the beginning of a bicycle ride.

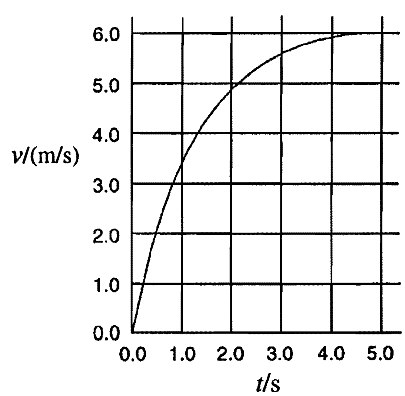


Fig. 8

(a) Describe the variation of the acceleration of the bicycle with time. [2]

(b) Use the graph to determine

(i) the speed at $t = 5.00$ s,

(ii) the acceleration at $t = 5.00$ s,

(iii) the approximate distance travelled in the first 5.00s.

speed =......... acceleration =......... distance =............ [4]

N95/II/1

49 (a) A small steel ball, dropped from rest, takes 0.50 s to fall through a vertical distance of 1.25 m. Determine

(i) the average speed of the ball,

(ii) the actual speed of the ball when it has fallen through a vertical distance of 1.25 m, assuming that the acceleration is constant,

(iii) the value of that acceleration . [4]

(b) An object dropped from an aircraft flying horizontally takes 20 s to reach a constant vertical speed of 100 m/s.

(i) In the space below, using labelled and scaled axes, sketch a graph to show the variation of the object's vertical speed with time over the first 25 s of the fall; label this graph 'T'.

(ii) On the same axes, sketch a graph of the variation of speed of any object falling freely (i.e. neglecting air resistance) from rest to a speed of 100 m/s; label this graph 'F'. The acceleration of free fall is 10 m/s^2. [4]

J96/II/1

50 Fig. 9 shows a trolley being pulled along a horizontal bench by means of the tension T in the thread fastened to the front of the trolley. The other end of the thread is attached to a mass-hanger.

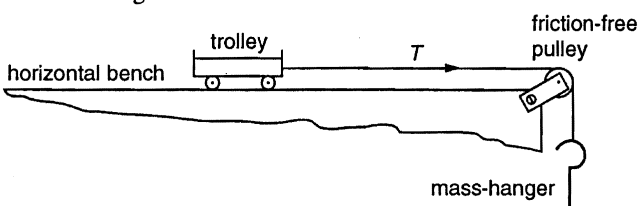


Fig. 9

A group of students times the motion of the trolley after it has been given a small initial push. They obtain the following data.

distance travelled/m	0.60	1.20	1.80
time / s	2.2	4.6	6.4

(a) Describe, in a few words, the motion of the trolley. Justify your answer. [3]

(b) Determine the average speed of the trolley. [2]

(c) The mass of the trolley is 1.4 kg and that of the mass-hanger is 15 g. The gravitational force on a mass of 1.0 kg is 10 N. Name and determine the magnitude of each of the four external forces acting on the trolley after it has been given the initial push. You may give your answers in any order. [2]

N96/II/1

51 Fig. 10 shows the variation of speed u with time t of a ball thrown vertically upwards into the air. Only the first 0.4 s of the graph has been plotted. In this question, air resistance can be neglected.

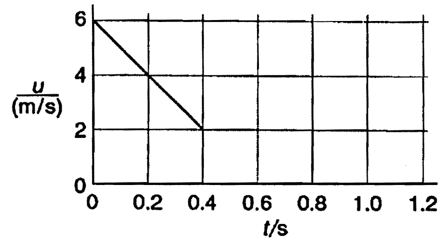


Fig. 10

(a) State what is meant by the *speed* of the ball. [1]

(b) Complete Fig. 10 to show the variation of the speed u with time t between $t = 0.4$ s and $t = 1.2$ s. [2]

(c) State the value of the time when the ball is at its highest point above the ground. [1]

(d) Determine the vertical distance covered by the ball in the first 0.4 s of its motion. [3]

J98/II/1

52 A parachutist jumps from an aircraft and falls through the air. After some time, the parachute opens.

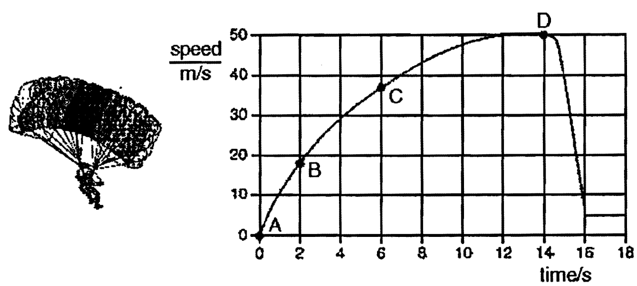


Fig. 11

Fig. 11 shows how the speed of the parachutist varies with time.

(a) Describe the motion of the parachutist between A and D. [3]

(b) State the value of the terminal velocity before and after the parachute opens.

before parachute opens, terminal velocity = ...

after parachute opens, terminal velocity = ...[1]

(c) Calculate the average value of the acceleration between B and C. [2]

J2000/II/1

ANSWERS

1. **E**	2. **C**	3. **B**	4. **C**	5. **B**
6. **C**	7. **D**	8. **A**	9. **A**	10. **E**
11. **C**	12. **B**	13. **D**	14. **D**	15. **C**
16. **A**	17. **A**	18. **D**	19. **C**	20. **B**
21. **C**	22. **A**	23. **C**	24. **C**	25. **B**
26. **C**				

27. *(a)* 30 m *(b)* 150 m , ≃ 30 m
28. 2.0 m/s^2 ; $t = 2.4$ s
39. *(a)* (i) 5 m/s^2 (ii) 15 m/s
(iii) 157.5 m
(b) 1.1 N
30. *(b)* 16.2 m
31. (i) 50 s (ii) 20 m
32. 150 m
33. *(a)* 4.0 m/s
(b) (i) 2.7 m/s^2 (ii) 5.3 m
(iii) 15.9 kJ
34. 360 m
36. 45 m
38. (i) 2.5 m/s (ii) 5.0 m/s
(iii) 0.625 m/s^2
39. *(b)* (i) 12.5 m/s (ii) 25 m/s
(iii) 12.5 m/s^2
40. *(a)* (i) 6 m/s (ii) 0.6 s
(c) 4 m
41. *(a)* 8 m/s *(c)* 2.35 m
42. *(a)* 0.6 m/s *(b)* 0.9 m/s
(c) 2.7 m
43. *(a)* (i) 3 m/s (ii) 15 m/s
(iii) 1.2 m/s^2
(b) (i) 90 m
44. *(a)* (i) 0 (ii) 20 m/s
(b) 0 *(c)* 8 m
45. *(a)* 1.2 m/s *(b)* 0.96 m
46. *(a)* (i) 37.7 cm (ii) 11.3 m/s
(b) (i) Clockwise
47. *(c)* (i) 0.8 m^{-1} (ii) 2.5 m/s
48. *(b)* (i) 6.0 m/s (ii) 0
(iii) 23 m
49. *(a)* (i) 2.50 m/s (ii) 5 m/s
(iii) 10 m/s
50. *(b)* 0.28 m/s
(c) Wt. of trolley = 14 N
Tension = 0.15 N
Friction = 0.15 N
Reaction = 14 N
51. *(c)* 0.6 s *(d)* 1.6 m
52. *(b)* 50 m/s ; 5 m/s *(c)* 4.75 m/s^2