SPEED-TIME

1 A young athlete has a mass of 42 kg. On a day when there is no wind, she runs a 100 m race in 14.2 s. A sketch graph (not to scale) showing her speed during the race is given in Fig. 1.1.

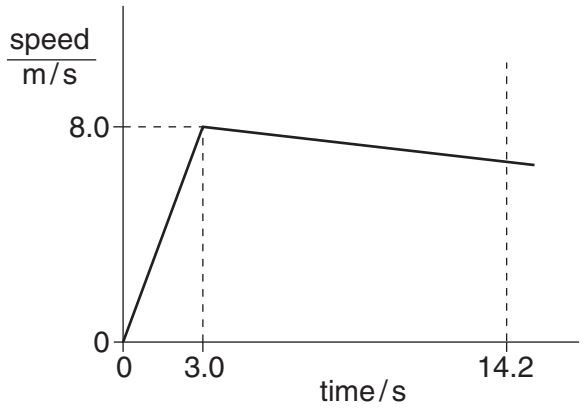

Fig. 1.1

(a) Calculate

(i) the acceleration of the athlete during the first 3.0 s of the race,

acceleration = ... [2]

(ii) the accelerating force on the athlete during the first 3.0 s of the race,

force = ... [2]

(iii) the speed with which she crosses the finishing line.

speed = ... [3]

(b) Suggest two differences that might be seen in the graph if there had been a strong wind opposing the runners in the race.

1. .....

.....

2. .....

..... [2]

[Total: 9]

MARKING SCHEME:

(a) **(i)** $(v - u)/t$ OR v/t OR 8/3 — C1
$2.7\ m/s^2$ — A1

(ii) ma OR 42 × answer from **(i)** OR 42 × 8/3 — C1
110/112 N e.c.f. — A1

(iii) (distance in 1^{st} 3 secs =) 12 m OR (dist in last 3 secs =) 88 m — C1
use of area of trapezium OR area of "top" triangle — C1
7.7 m/s — A1

(b) longer time to top speed)
longer total time)
lower top speed)
lower finishing speed) any 2 — B1+B1
specific/all speeds lower (**not** speed decreases))
less slope/less acceleration (in first section))
greater slope/greater deceleration in 2^{nd} section)

[Total: 9]

2 **(a)** Define *acceleration*. Explain any symbols in your definition.

.....

.....[1]

(b) Fig. 1.1 shows a graph of speed against time for a train. After 100 s the train stops at a station.

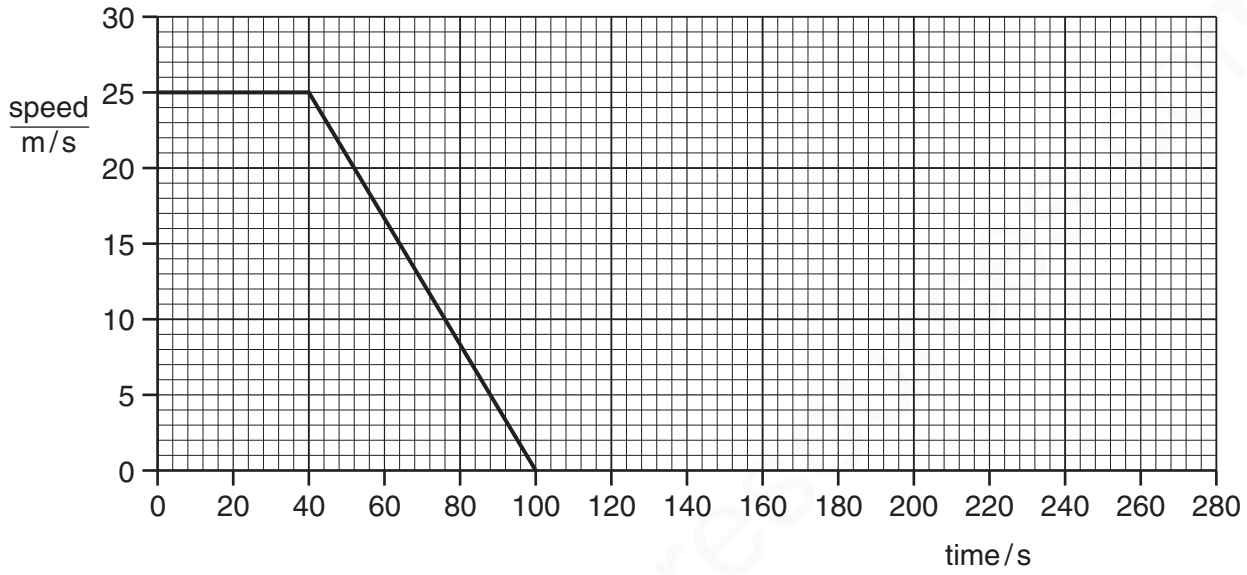

Fig. 1.1

(i) For the time interval between 40 s and 100 s, calculate the distance travelled by the train.

distance = ...[2]

(ii) The train stops for 80 s, then accelerates to 30 m/s with an acceleration of 0.60 m/s^2. It then travels at constant speed.

Complete the graph for the interval 100 s to 280 s, showing your calculations in the space below.

[5]

[Total: 8]

MARKING SCHEME:

(a) acceleration = $\frac{v-u}{t}$ OR $\frac{\Delta v}{t}$ (symbols used to be explained)
OR change of velocity ÷ time
OR rate of change of velocity
OR change of velocity per second / in 1 sec (allow 'in a certain time') B1
accept speed for velocity

(b) **(i)** use of any area under graph C1
750 m A1

(ii) time = change of speed ÷ acceleration OR 30/0.60 C1
= 50 (s) A1
if working for t = 50 s not shown, allow 2 marks for correct use of 50 s
graph: along y-axis to 180 s / rise starts at 180 s B1
from x-axis rises to 30 m/s at 230 s / candidate's calculated time B1
horizontal from top of slope to 280 s B1 [8]
allow ½ square tolerance at 180 s where relevant
allow ecf from wrong t

3 **(a)** Fig. 1.1 shows the distance-time graphs for three different objects A, B and C.

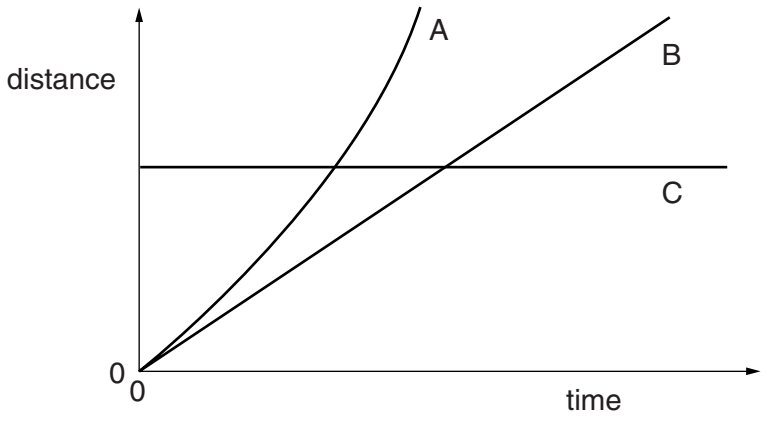

Fig. 1.1

Describe the motion of each of the objects A, B and C by selecting the appropriate description from the list below.

constant speed increasing speed decreasing speed stationary

A .....

B .....

C .....

[2]

(b) Fig. 1.2 shows the speed-time graphs for three more objects D, E, and F.

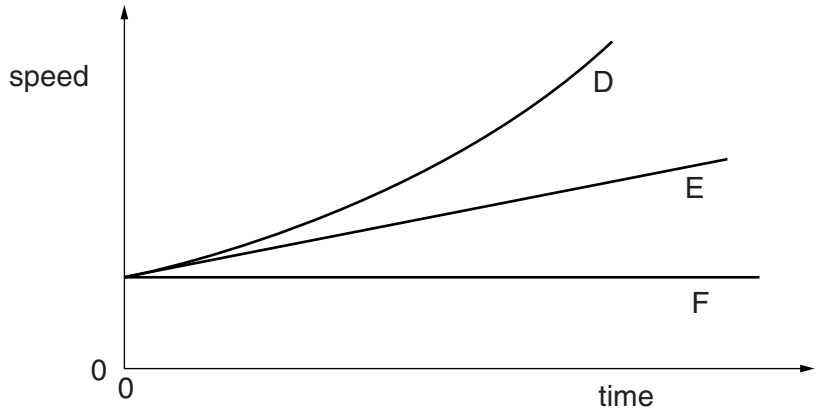

Fig. 1.2

Describe the motion of each of the objects D, E and F by selecting the appropriate description from the list below.

constant speed constant acceleration increasing acceleration stationary

D .....

E .....

F .....

[2]

MARKING SCHEME:

(a) A increasing speed
B constant speed
C stationary B2
Note: one mark lost for e.e.o.o.

(b) D increasing acceleration
E constant acceleration
F constant speed B2
Note: one mark lost for e.e.o.o.

4 Fig. 1.1 shows a rocket-powered sled travelling along a straight track. The sled is used to test components before they are sent into space.

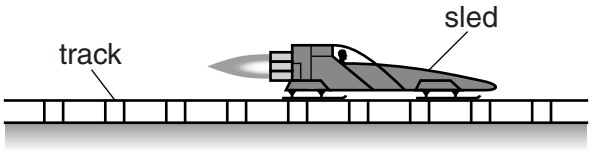

Fig. 1.1

Fig. 1.2 is the speed-time graph for the sled from time $t = 0$ s.

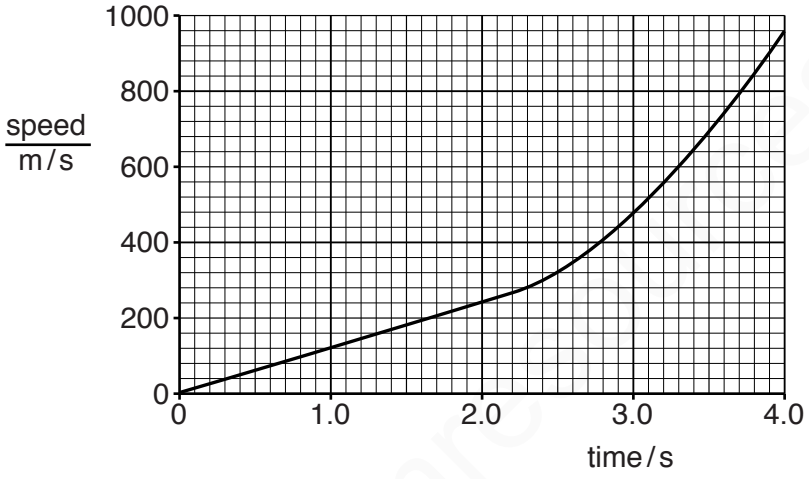

Fig. 1.2

(a) On Fig. 1.2, mark a point labelled P to indicate a time when the acceleration of the sled is not constant. [1]

(b) **(i)** Calculate the acceleration of the sled at $t = 1.0$ s.

acceleration = ...[2]

(ii) Determine the distance travelled by the sled between $t = 1.0$ s and $t = 2.0$ s.

distance = ...[2]

(c) The resultant force acting on the sled remains constant during the test.

Suggest why the acceleration of the sled is not constant.

.....

.....[1]

[Total: 6]

MARKING SCHEME:

(a)		point marked P (on line or time axis) at $t \geq 2.0$ s	B1
(b)	**(i)**	attempt at gradient OR ($a =$) $\Delta v / t$ OR $(v - u)/t$ OR $240 (-0)/2.0$ OR division of correct points on graph	C1
		$120\,m/s^2$	A1
	(ii)	suggestion of area (under graph) in words or formula or numbers OR $0.5\,(120 + 240) \times 1.0$ OR $[(120 \times 1.0) + (0.5 \times 120 \times 1.0)]$	C1
		180 m	A1
(c)		mass of sled changes / decreases OR fuel used up	B1

[Total: 6]

5 **(a)** Figs. 1.1 and 1.2 show speed-time graphs for two objects, each moving in a straight line.

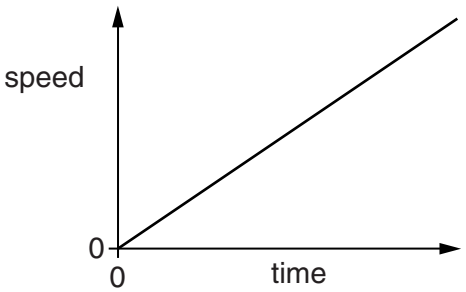

Fig. 1.1

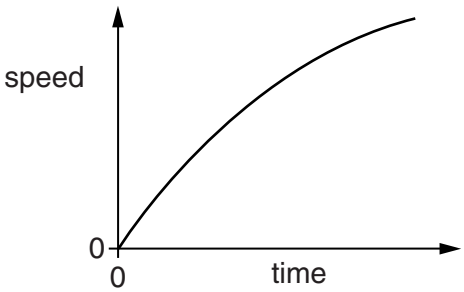

Fig. 1.2

(i) Describe the motion of the object shown by the graph in Fig. 1.1.

.....

.....

(ii) Describe the motion of the object shown by the graph in Fig. 1.2.

.....

.....

[3]

(b) On a day with no wind, a large object is dropped from a tall building. The object experiences air resistance during its fall to the ground.

State and explain, in terms of the forces acting, how the acceleration of the object varies during its fall.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 7]

MARKING SCHEME:

(a)	**(i)**	acceleration OR increasing speed	C1
		constant acceleration OR constant rate of increase in speed	A1
	(ii)	decreasing acceleration OR decreasing rate of increase in speed NOT deceleration	B1
(b)		mention of air resistance AND weight (of object) / force due to gravity	B1
		acceleration at start (of fall) is acceleration of gravity / 10 m / s^2 / a maximum / *g* OR acceleration decreases (as it falls)	B1
		air resistance increases as speed increases/as it accelerates	B1
		acceleration zero/terminal velocity/constant speed/maximum speed when air resistance = weight	B1

[Total: 7]

6 At a sports event, a champion runner and a car take part in a race.

(a) The runner runs at a constant speed of 10 m/s from the start of the race. During the first 5.0 s of the race, the car's speed increases from 0 m/s to 25 m/s at a uniform rate.

On Fig. 1.1, draw

(i) a graph to show the motion of the runner, [1]

(ii) a graph to show the motion of the car.

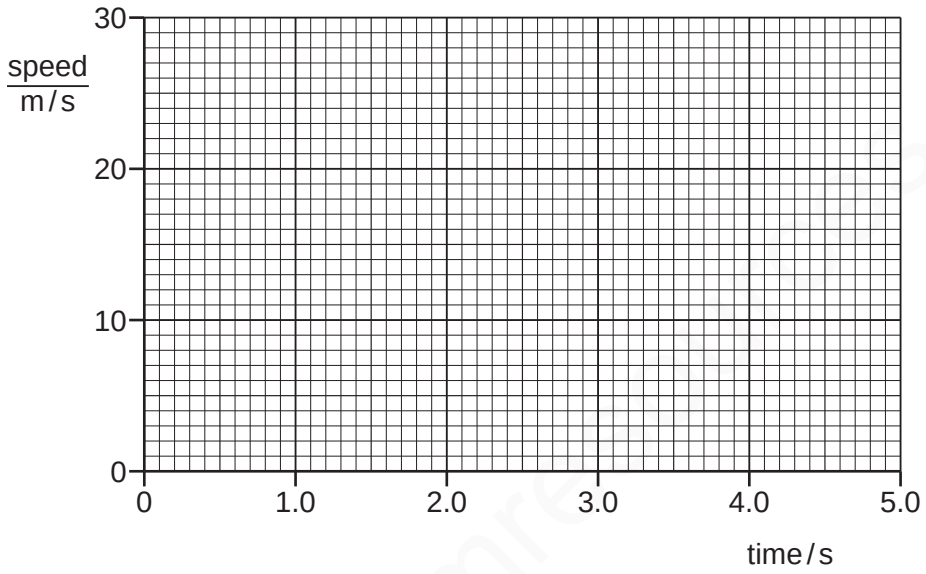

Fig. 1.1

[1]

(b) Use your graphs to determine

(i) the distance travelled by the runner in the 5.0 s,

distance = ...[1]

(ii) the distance travelled by the car in the 5.0 s,

distance = ...[2]

(iii) the time at which the car overtakes the runner.

time = ...[2]

[Total: 7]

MARKING SCHEME:

(a)	**(i)**	horizontal line at 10 m / s	B1
	(ii)	straight line from origin to (5.0, 25)	B1
(b)	**(i)**	50 m	B1
	(ii)	area of triangle OR ½ × 25 × 5.0	C1
		62.5 m OR 63 m	A1
	(iii)	when areas under graphs are equal	C1
		4.0 s	A1

[Total: 7]