MOTION-SET-1-QP-MS

1 **(a)** **(i)** A car travelling at 60 km / h has four times the kinetic energy of the same car travelling at 30 km / h.

Explain this by means of a calculation.

[2]

(ii) Use your answer to **(i)** to explain why the speed of a car involved in an accident with a pedestrian makes such a big difference to the injuries caused.

....

....

.... [2]

(b) A car of mass 1000 kg is travelling along a road. The driver applies the brakes which give a constant force of 4000 N.

(i) Calculate the deceleration of the car.

Show your working and state any formula that you use.

.... [2]

(ii) The car took 32 metres to stop.

Use the formula

distance = $^1/_2\,at^2$

to calculate the time taken to stop.

.... [2]

MARKING SCHEME

(a) (i) KE = $^1/_2\ mv^2$ *or* obvious use of this relationship in calculation;
calculation of KE at the two speeds *and* one shown to be four times the other; 2

(ii) *small* increase in speed means *large* increase in kinetic energy;
degree of injury is related to kinetic energy (at impact); 2

(b) (i) force = mass x acceleration/acceleration = 4000 ÷ 1000;
$4 m/s^2$; 2

(ii) $32 = 0.5 \times 4 \times t^2$;
t = 4 seconds. 2

Total 8 marks

2 Fig. 7.1 shows three aeroplanes at an airport.

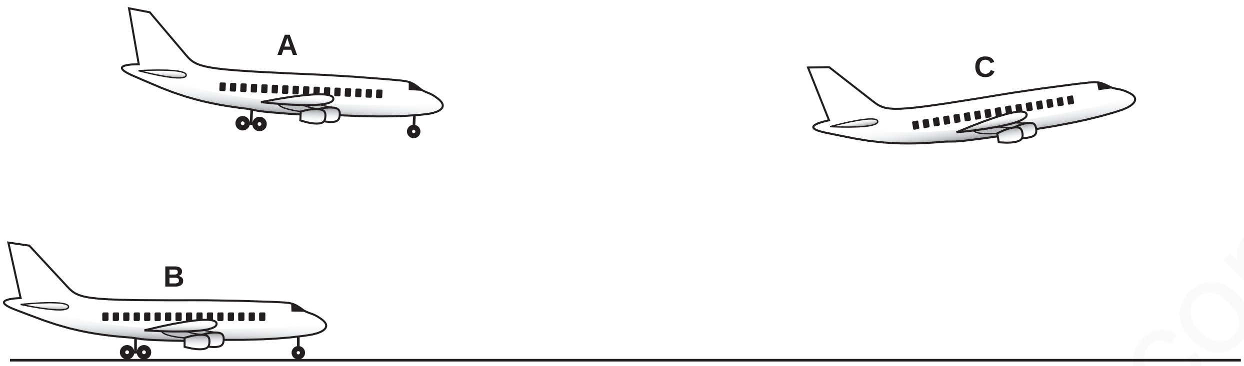


Fig. 7.1

(a) Aeroplane **A** is moving at a constant velocity towards the main runway.
Aeroplane **B** is stationary, waiting for take off.
Aeroplane **C** has just taken off and is accelerating.

(i) Which, if any, of the aeroplanes has zero momentum?

Explain your answer.

....

.... [1]

(ii) The momentum of one of the aeroplanes is changing.

State which aeroplane and explain your answer.

....

.... [1]

(b) Fig. 7.2 shows a speed-time graph for aeroplane **C**.

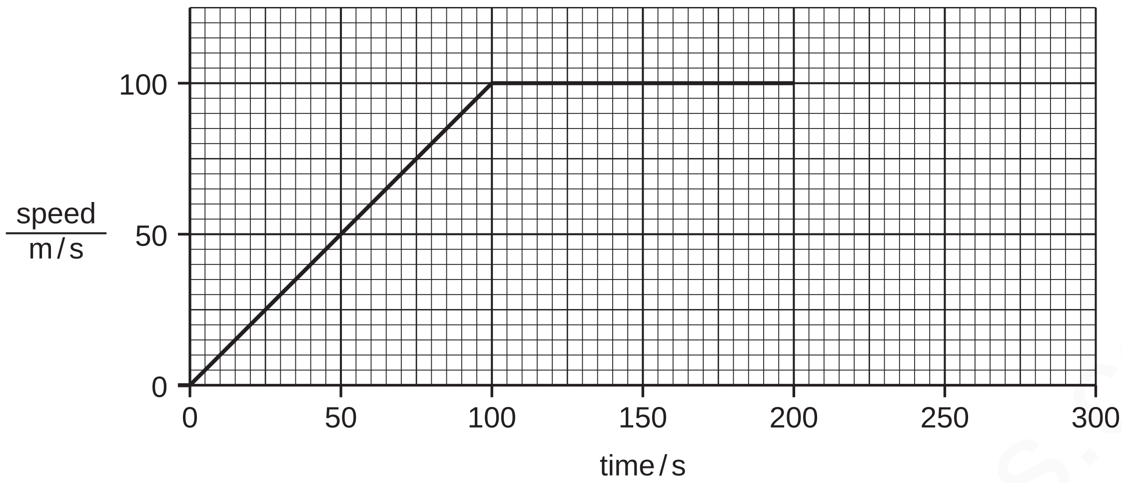


Fig. 7.2

Calculate the distance covered by the aeroplane in the first 200 seconds.
Show your working.

.... [2]

(c) The mass of aeroplane **C** is 120 000 kg.
Calculate the kinetic energy of the aeroplane as it travels at 100 m / s.

Show your working and state the formula that you use.

formula used

working

.... [3]

MARKING SCHEME

(a) **(i)** (airplane B)
no velocity / not moving; [1]

(ii) (airplane C)
velocity is increasing so momentum increases; [1]

(b) area under graph or working;
15 000 m; [2]

(c) KE = 1/2 mv^2;
= 0.5 x 120 000 x 100 x 100
= 600 MJ; [3]

[Total: 7]

3 **(a)** A car of mass 1200 kg is travelling forward at a constant speed of 20 m / s.
Fig. 3.1 shows the driving force and the frictional force acting on the car.

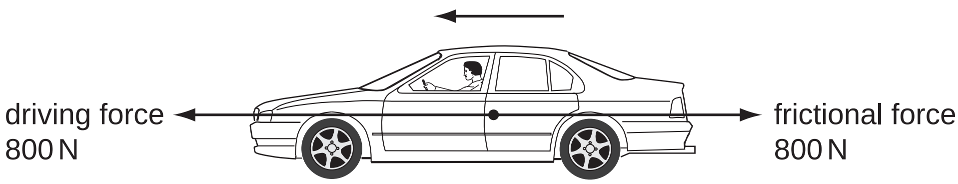


Fig. 3.1

(i) Calculate the work done by the driving force in 30 seconds.

State the formula that you use and show your working.

formula used

working

.... [3]

(ii) Calculate the kinetic energy of the car travelling at 20 m / s.

State the formula that you use and show your working.

formula used

working

.... [2]

(b) A pedestrian steps into the path of the moving car. Fig. 3.2 shows a graph of how the speed of the car changes from the moment when the driver sees the pedestrian until the car stops.

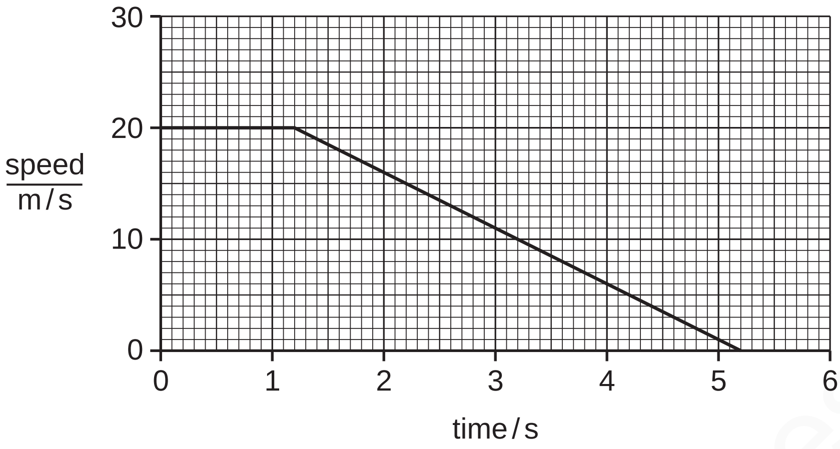


Fig. 3.2

(i) After 1.2 s the car slows down.

Calculate the deceleration of the car.

State the formula that you use and show your working.

formula used

working

.... [2]

(ii) Calculate the total distance travelled by the car between the driver seeing the pedestrian and the car stopping.

Show your working.

.... [3]

MARKING SCHEME

(a) (i) work = force × distance ;
distance travelled = 20 × 30 = 600m / use of 600 in correct context ;
(800 × 600) 480 000J ; [3]

(ii) kinetic energy = ½ mv^2;
= ½ × 1200 × 20 × 20 = 240 000 J; [2]

(b) (i) deceleration = change in speed / time;
= 20/4 = 5 m/s^2; [2]

(ii) reaction distance = 24m; (or working)
braking distance = 40m; (or working)
total distance = 64m; [3]

4 Two skiers **A** and **B** start a straight downhill race.

Fig 8.1 shows how the motion of skier **A** changes during the race. Skier **A** finishes the race after 40 seconds and then slows down and stops after 50 seconds.

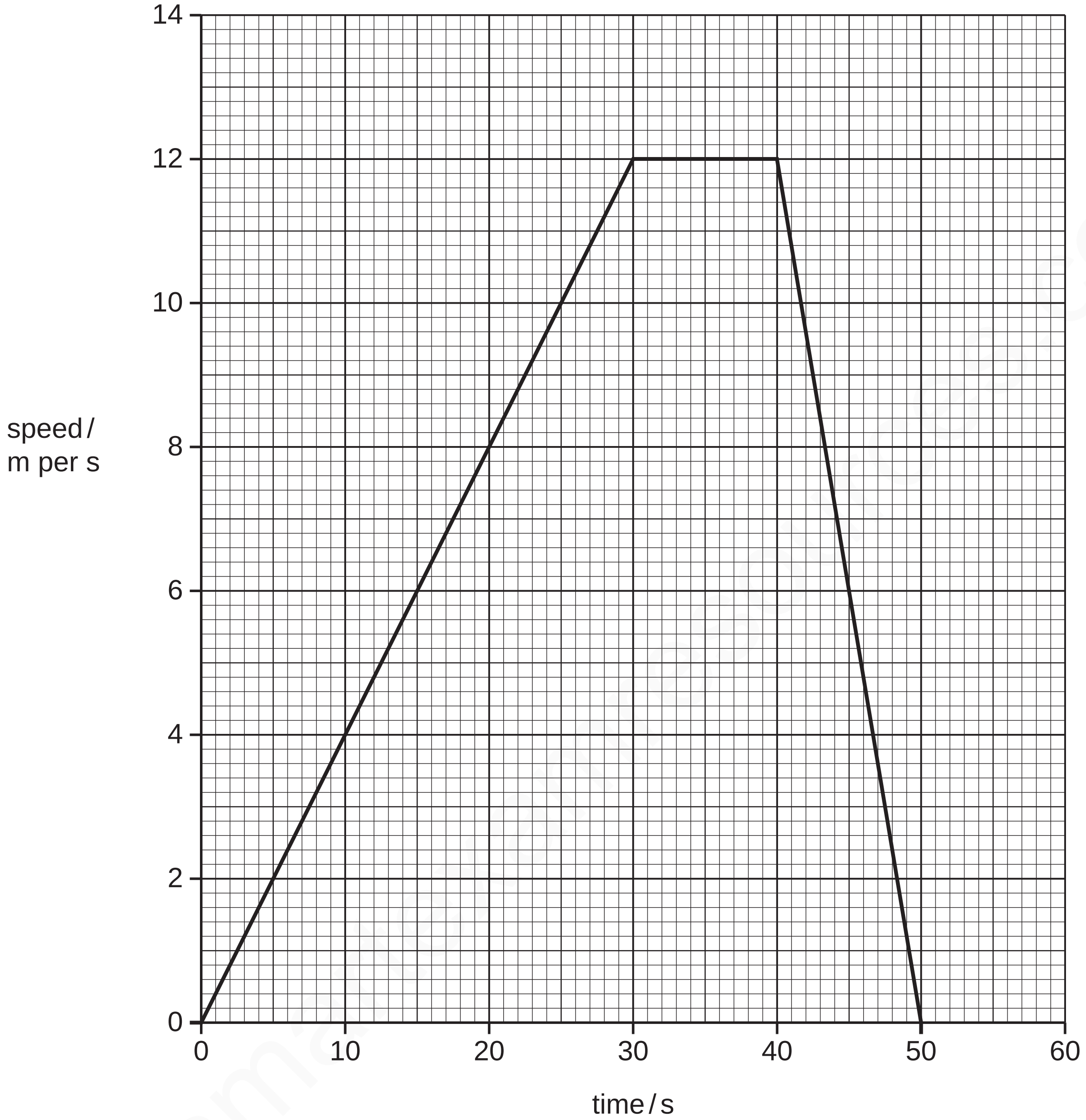


Fig. 8.1

(a) **(i)** Describe the motion of skier **A** between 0 and 30 seconds.

....

.... [2]

(ii) Calculate the distance skier **A** travels between 0 and 30 seconds.

Show your working.

.... [2]

(b) The mass of skier **A** is 60 kg. Calculate the kinetic energy of the skier when her speed is 10 m / s.

State the formula that you use and show your working.

formula

working

.... [2]

(c) (i) Calculate the deceleration of skier **A** between 40 and 50 seconds.

State the formula that you use and show your working.

formula

working

.... [2]

(ii) Calculate the force on skier **A** which causes this deceleration.

State the formula that you use and show your working.

formula

working

.... [2]

(d) Skier **B** wins the race. On Fig. 8.1 show how the motion of skier **B** might change during the race.

Explain your answer.

....

.... [2]

MARKING SCHEME

(a) **(i)** constant/steady/uniform/0.4 ms^{-2} ;
acceleration ; [2]

(ii) ½ x 30 x 12 ;
= 180 m ; [2]

(b) (KE =) ½ mv^2 ;
= ½ x 60 x 10 x 10 = 3000 J ; [2]

(c) **(i)** (acceleration/deceleration = change in) speed/time = 12/10 ;
= 1.2 m/s^2 ; [2]

(ii) (force =) mass x acceleration ;
= 60 x 1.2 = 72 N ; [2]

(d) on graph – initial acceleration steeper/steady speed higher ;
greater acceleration/greater top speed by 38 s ;
[explanation must match what is shown on graph] [2]

[Total: 12]

5 **(a)** A racing car is being driven in a race.

The graph in Fig. 8.1 shows the speed of the car over a 26 second period.

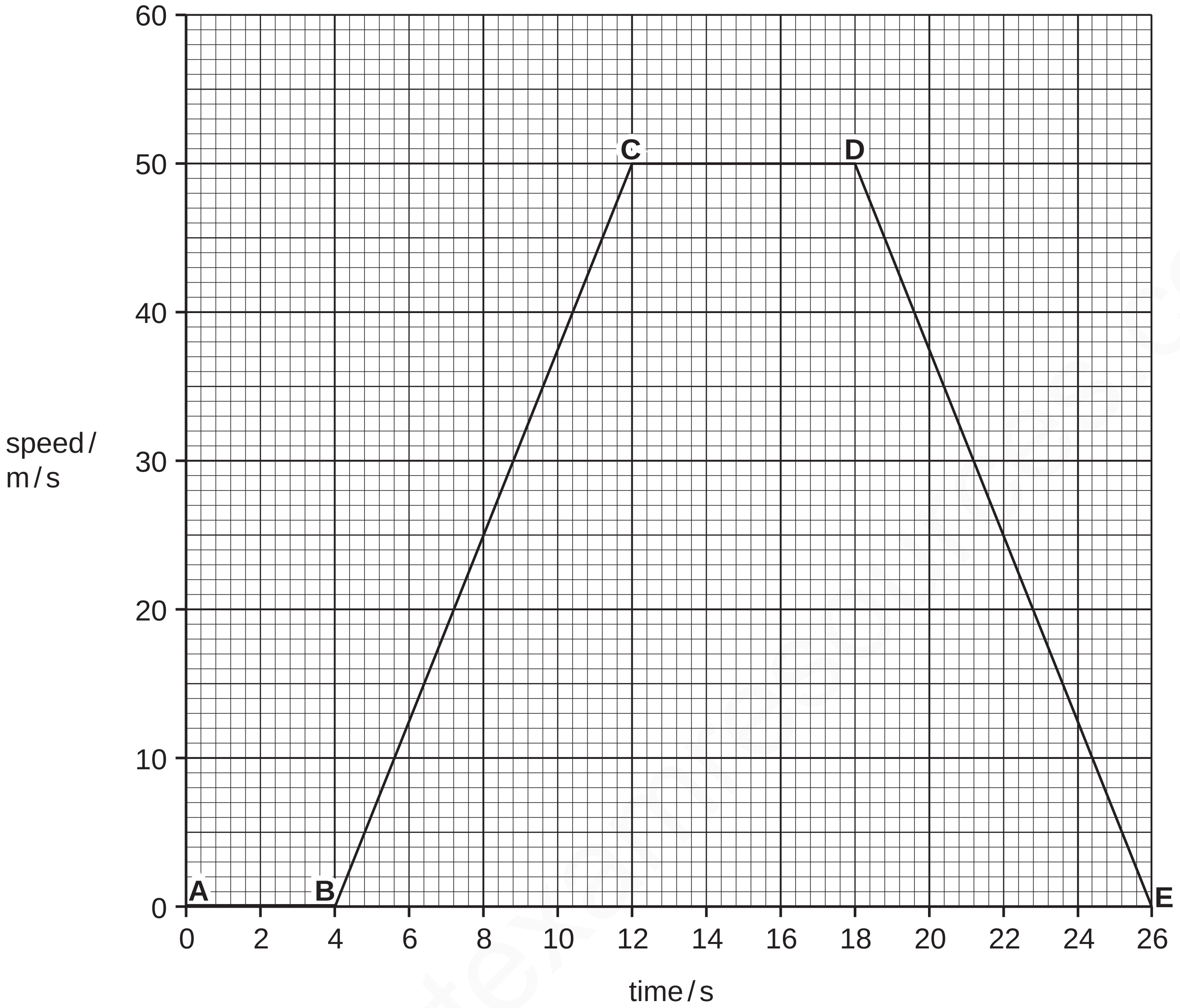


Fig. 8.1

(i) Between which points on the graph is the car not moving?

.... [1]

(ii) Calculate the acceleration of the car between **B** and **C**.

Show your working.

.... [2]

(b) A wheel on a car needs changing. Fig. 8.2 shows a spanner being used to turn a wheel nut.

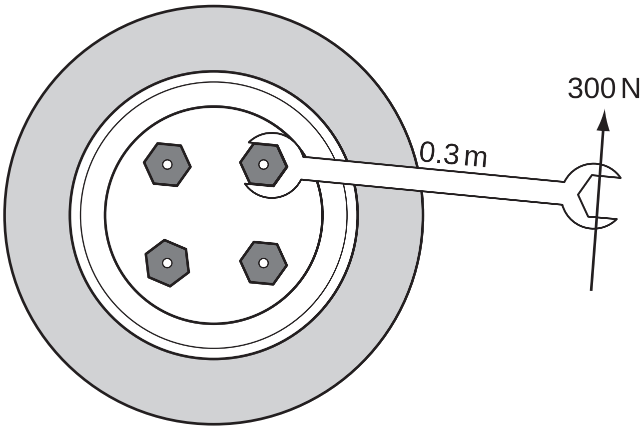


Fig. 8.2

(i) Calculate the turning effect (moment) of the spanner.

State the formula that you use and show your working.

formula

working

.... [2]

(ii) Give **two** ways in which you could increase the spanner's turning effect.

1 ....

....

2 ....

.... [2]

(c) During a race the air in the tyre is at a temperature of 400 K and a pressure of 120 000 N / m^2. After the race, the air in the tyre cools down to a temperature of 300 K.

Calculate the new air pressure in the tyre.

State the formula that you use and show your working.

formula

working

.... [3]

MARKING SCHEME

(a) **(i)** **A** to **B** ; [1]

(ii) acceleration = gradient (or use numbers) ;
= 50 / 8 = 6.25 m / s^2 ; [2]

(b) **(i)** (turning effect =) force × distance ;
= 0.3 × 300 = 90 Nm ; [2]

(ii) increase force ;
increase distance / use a longer spanner ; [2]

(c) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$;
120 000/400 = P_2/300 (or other correct substitution) ;
P_2 = 90 000 N / m^2 ; [3]

[Total: 10]

6 **(a)** Fig. 7.1 shows how radar is used to detect aircraft. Radar uses microwaves with a frequency of about 10 000 MHz. Short microwave pulses are sent from the transmitter, reflected from the aircraft and received. The time it takes for the wave pulse to make the journey there and back is measured.

Microwave pulses travel at 300 000 000 m / s.

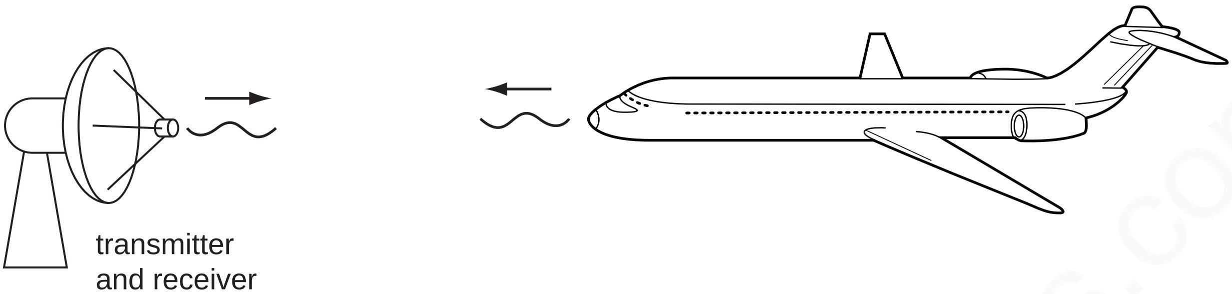


Fig. 7.1

(i) Calculate the wavelength of the microwaves.

State the formula that you use and show your working.

formula used

working

.... [2]

(ii) A radar transmitter sends a microwave pulse which is reflected from the aircraft. The microwave pulse returns to the receiver 0.000 027 s after transmission.

Calculate the distance of the aircraft from the radar transmitter.

State the formula that you use and show your working.

formula used

working

.... [2]

(b) The mass of the aircraft is 140 000 kg.

Calculate the kinetic energy of the aircraft as it travels at 100 m / s.

State the formula that you use and show your working.

formula used

working

.... [2]

(c) As the aircraft lands it is travelling at 85 m / s. It moves along the runway and decelerates at a uniform rate for 40 s until it stops.

(i) Calculate the deceleration of the aircraft along the runway.

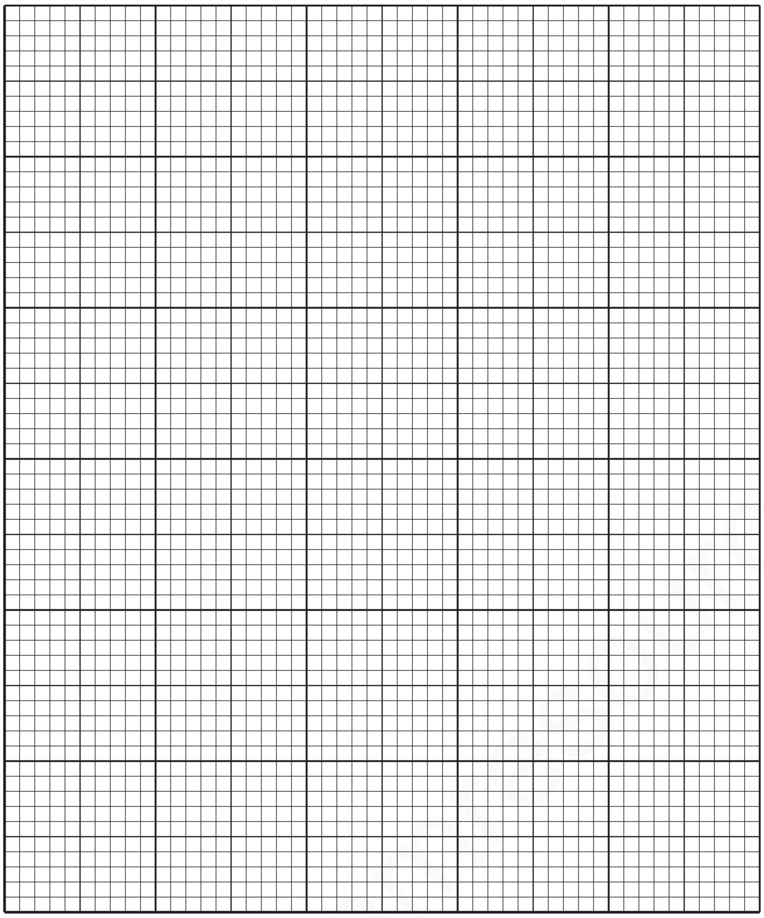
State the formula that you use and show your working.

formula used

working

.... [2]

(ii) On the grid, draw a speed-time graph for the aircraft as it slows down from 85 m / s until it stops.



[3]

MARKING SCHEME

(a) (i) (λ =) v / f **or** v = f × λ

300 000 000 / 10 000 000 000 = 0.03 m ; [2]

(ii) (distance =) speed × time ;
= 300 000 000 × 0.000 027 = 8100 m so distance = 4050 m ; [2]

(b) (KE =) ½ mv^2 ;
= ½ × 140000 × 100 × 100 = 7 × 10^8 J ; [2]

(c) (i) (deceleration =) change in velocity / time ;
(= 85/40 =) 2.125 m / s^2 ; [2]

(ii) suitable axes and scales ;
straight line ;
from 85 m / s at **t** = 0 to 0 m / s at **t** = 40 ; [3]

[Total: 11]

7 Fig. 7.1 shows a crane for use on building sites.

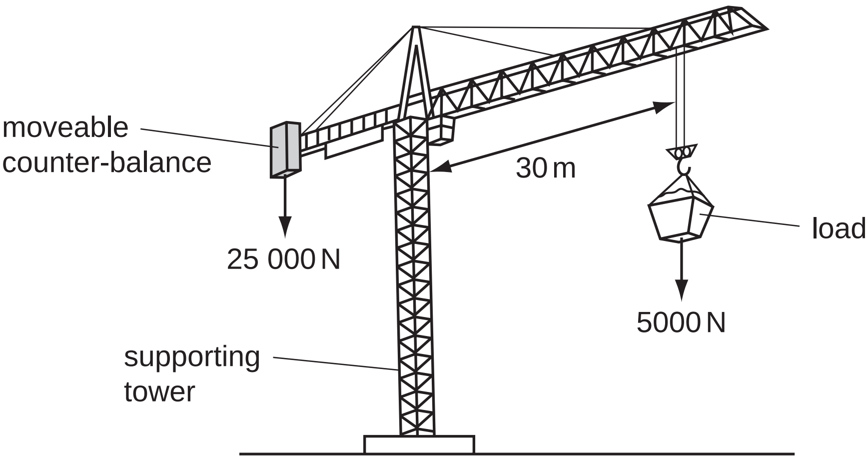


Fig. 7.1

(a) Explain in terms of forces why the crane needs a counter-balance.

....

....

.... [2]

(b) The crane in Fig. 7.1 is balanced.

Calculate the moment of the load about the crane's supporting tower. Then calculate the distance of the counterbalance from the crane's supporting tower.

State the formula that you use for your calculations and show your working.

formula used

working

moment of load ....

distance of counterbalance .... [3]

(c) A brick falls from the crane and hits the ground at a speed of 40 m / s. The air resistance on the brick can be ignored.

(i) The acceleration due to gravity is 10 m / s^2.

Calculate the time of the fall.

State the formula that you use and show your working.

formula used

working

.... [2]

(ii) On the grid below, draw the speed-time graph for the falling brick.

[3]

(iii) The brick has a mass of 2 kg.

Calculate the kinetic energy of the brick as it hits the ground.

State the formula that you use and show your working.

formula used

working

.... [2]

(iv) State the value of the potential energy of the brick, before it fell from the crane.

Explain your answer.

potential energy ....

explanation ....

.... [2]

MARKING SCHEME

(a) clockwise moment has to equal anticlockwise moment / $F_1d_1 = F_2d_2$, owtte ;
to stop crane tipping over when lifting weight ; [2]

(b) (moment =) force × distance / weight × distance ;
(= 5000 × 30) = 150 000 Nm ;
(150 000 / 25 000) = 6 m ; [3]

(c) **(i)** v – u = at **or** (t =) $\frac{v - u}{a}$;
t = 40 / 10 = 4 s ; [2]

(ii) suitable scales and axes labelled with quantities and units ;
straight line ;
from 0 m / s at t = 0 to 40 m / s at t = 4 ; [3]

(iii) (KE =) $\frac{1}{2}mv^2$;
= 0.5 × 2 × 40 × 40 = 1600 J ; [2]

(iv) 1600 (J) ;
energy is conserved ; [2]

[Total:14]