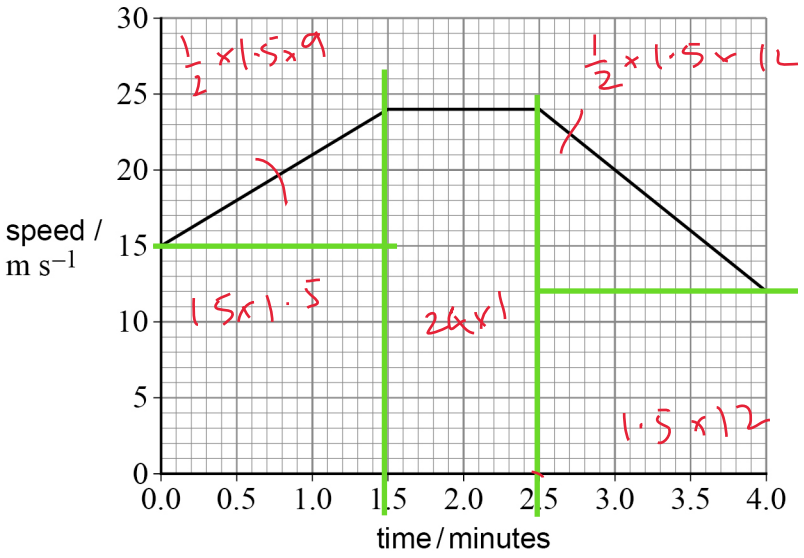
Do not write outside the box

0 4 A pair of cameras is used on a motorway to help determine the average speed of vehicles travelling between the two cameras.

Figure 5 shows the speed–time graph for a car moving between the two cameras.

Figure 5



0 4 . 1 The speed limit for the motorway between the two cameras is 22 m s^{-1}.

Determine whether the average speed of the car exceeded this speed limit.

[3 marks]

$d = (22.5 + 6.75 + 24 + 9 + 18) \times 60 = 4815\text{m}$

$t = 4 \times 60 = 240$

$\therefore v_{av} = \frac{4815}{240} = 20.1\text{ m/s}$ SOON

Question 4 continues on the next page

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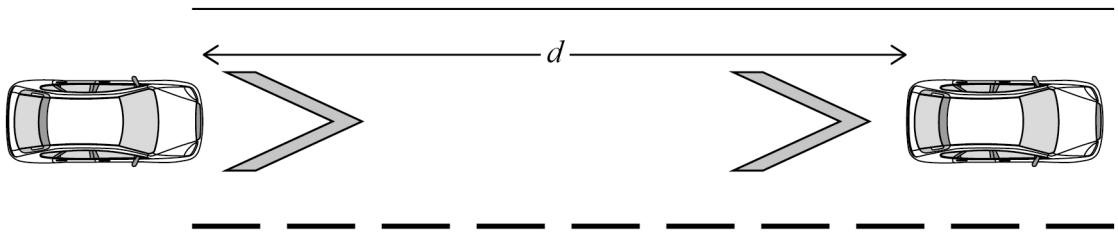
0 4 . 2 Markings called chevrons are used on motorways.

The chevron separation is designed to give a driver time to respond to any change in speed of the car in front. The driver is advised to keep a minimum distance d behind the car in front, as shown in **Figure 6**.

Figure 6



not to scale

Government research suggests that the typical time for a driver to respond is between 1.6 s and 2.0 s.

Suggest a value for d where the speed limit is $31\ \text{m s}^{-1}$.

[2 marks]

Use worse case - 2.0s
v=31m/s therefore distance = 2x31=62m

$d =$ _____ m

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0 4 . 3 The chevron separation is based on the response time, not on the time taken for a car to stop.

The brakes of a car are applied when its speed is $31\ \text{m s}^{-1}$ and the car comes to rest. The total mass of the car is $1200\ \text{kg}$.

The average braking force acting on the car is $6.8\ \text{kN}$.

Calculate the time taken for the braking force to stop the car **and** the distance travelled by the car in this time.

[4 marks]

$F \times \Delta t = \Delta p \Rightarrow \Delta t = \frac{31 \times 1200}{6.8k}$

$= 5.47\ \text{sec}$

$\frac{F}{m} = a = \frac{6800}{1200} = 5.67\ \text{m/s}^2$

$v^2 = u^2 + 2as \Rightarrow \frac{v^2 - u^2}{2a} = s$ ($v = 0$, $u = 31$)

time = 5.5 s

distance = 85 m

0 4 . 4 Suggest why the chevron separation on motorways does not take into account the distance travelled as a car comes to rest after the brakes are applied.

[1 mark]

Question 4 continues on the next page

Turn over ►

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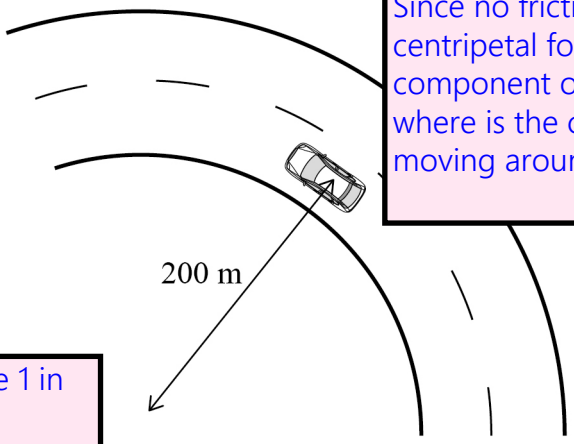
0 4 . 5 At bends on motorways the road is sloped so that a car is less likely to slide out of its lane when travelling at a high speed.

Figure 7 shows a car of mass $1200\ \text{kg}$ travelling around a curve of radius $200\ \text{m}$. The motorway is sloped at an angle of $5.0°$.

Figure 8 shows the weight W and reaction force N acting on the car. The advisory speed for the bend is chosen so that the friction force down the slope is zero.

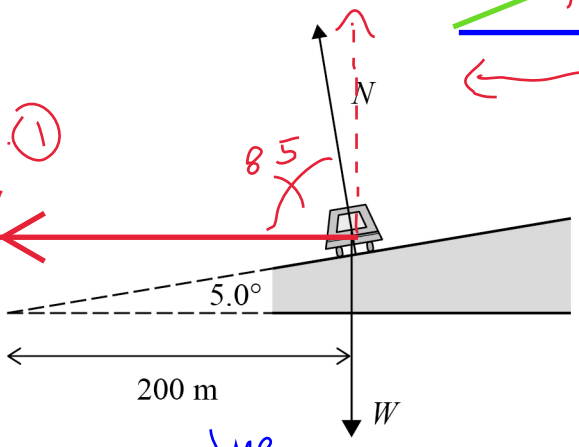
Figure 7

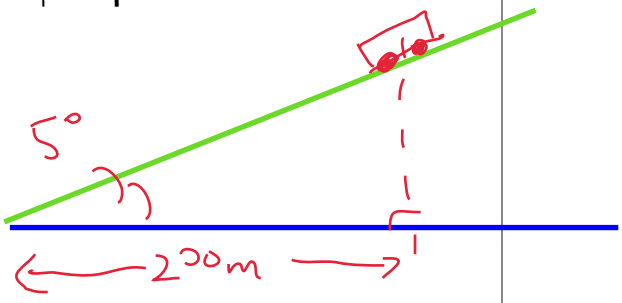


this is a complex way to say 'no friction'
Since no friction this means that the only centripetal force is going to be the horizontal component of the N (not down the slope, think where is the centre of the circle the car is moving around)

it might be more useful to have 1 in terms of 5 degrees = Nsin(5)

Figure 8





$\frac{mv^2}{r} = N\cos(85)$ ... ①

$N\cos 5 = W$

$N = \frac{W}{\cos 5}$ ... ②

sub for N in ①

$\frac{mv^2}{r} = \frac{W}{\cos 5}\cos(85)$ ~ replace with sin 5

$\Rightarrow \frac{mv^2}{r} = W\frac{\sin 5}{\cos 5}$ ($\frac{\sin}{\cos} = \tan$)

$\Rightarrow \frac{mv^2}{r} = mg\tan 5°$ ($W = mg$)

$\Rightarrow \frac{v^2}{r} = g\tan(5°) \Rightarrow v^2 = rg\tan(5) \Rightarrow v = 13\ \text{m/s}$

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Suggest an appropriate advisory speed for this section of the motorway.

[4 marks]

advisory speed = _____ $m\ s^{-1}$

14

Turn over for the next question

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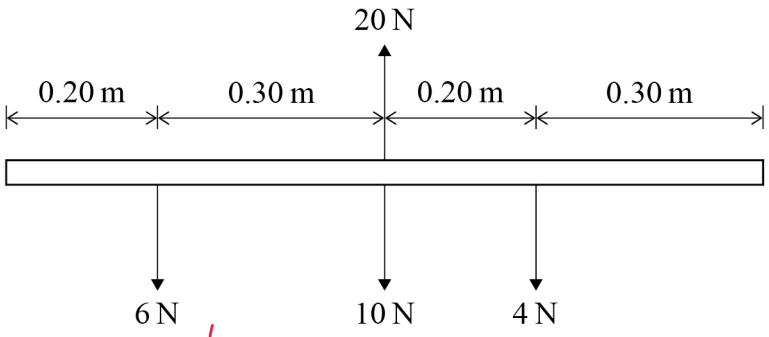
2 0 The diagram shows the forces acting on a uniform rod.



Which statement is correct?

[1 mark]

A The rod is in equilibrium. ⬭

B For equilibrium, an anticlockwise moment of 1.0 N m is needed. ⬭

C For equilibrium, a clockwise moment of 1.0 N m is needed. ⬭

D For equilibrium, the 10 N force should be increased to 20 N. ⬭

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2 1 Small water drops leave a tap with zero velocity at intervals of 0.20 s. They then fall freely 0.80 m to reach a horizontal surface.

How far has a drop fallen when the previous drop hits the surface?

[1 mark]

How long to hit the surface

$s = ut + \frac{1}{2}at^2 \Rightarrow \sqrt{\frac{2s}{a}} = t = 0.4\ sec$

A 0.16 m ⬭

B 0.20 m ⬭

so 2nd drop will have had 0.4-0.2 sec to fall in

C 0.40 m ⬭

$s = ut + \frac{1}{2}at^2 \Rightarrow 2 = \frac{1}{2} \times 9.8 \times 0.2^2$

D 0.60 m ⬭

$= 0.196\ m = 0.2$

2 2 A pellet with velocity 200 m s^{-1} and mass 5.0 g is fired vertically upwards into a stationary block of mass 95.0 g. The pellet remains in the block. The impact causes the block to move vertically upwards.

What is the maximum vertical displacement of the block?

[1 mark]

don't know if Ek is conserved in collision so use momentum

A 5.1 m ⬭

$P_{before} = 5g \times 200 = 1\ kg\ m/s$

B 10 m ⬭

$\therefore P_{after} = 1 = mv \Rightarrow v = 10\ m/s$

C 51 m ⬭

D 100 m ⬭

$0 \quad 10 \quad 100g \quad -9.8$

now $v^2 = u^2 + 2as \quad \frac{v^2 - u^2}{-2 \times 9.8} = 5.1m$

[1 mark]

Turn over ►