5 A car makes a turn on a road where the radius of curvature of the bend is r. The maximum safe speed v that a car can turn around a bend without sliding depends on the maximum frictional force exerted by the road on the tyres of the car. This force depends on the coefficient of static friction between two surfaces μ. The coefficient of static friction is given by:

$$\mu = \frac{v^2}{rg}$$

where g is the acceleration of free fall.

Data relating r and v^2 for a car travelling on crushed rocks are given in Table 5.1 and the variation with r of v^2 for different road surfaces are shown in Fig. 5.1.

Table 5.1

r / m	v^2 / km^2 h^{-2}
10.0	826
20.0	1653
30.0	2479
40.0	3306
50.0	4132
60.0	4958
70.0	5785

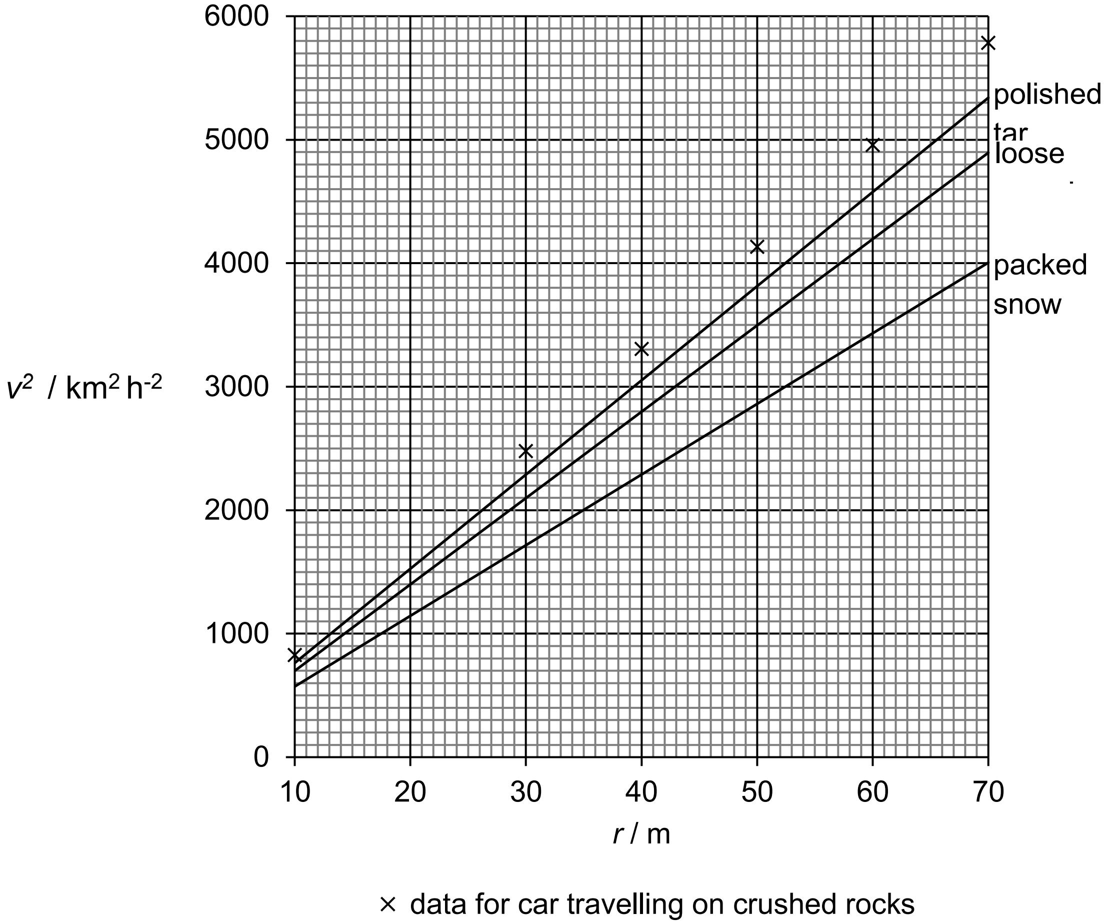

Fig. 5.1

(a) **(i)** Plot the point for $r = 20.0$ m on Fig. 5.1 for a car travelling on crushed rocks. [1]

(ii) Complete Fig. 5.1 by drawing the line of best fit for the data representing the car travelling on crushed rocks. [1]

(b) Use Fig. 5.1 to determine the coefficient of static friction when the car travels on polished tar.

coefficient of static friction = ……………………… [3]

A car travelling on loose gravel makes a turn with a radius of curvature 50.0 m at the maximum safe speed. Just after making the turn, the car crashes straight into a static concrete barrier and comes to a halt. The front portion of the car crumples resulting in the body of the car stopping after a distance of 30 cm. The driver whose mass is 70.0 kg is launched forward after the frontal collision.

The fatality of the collision depends on whether a seat belt was worn. Without wearing a seat belt, the driver will be launched forward upon impact and subsequently hit the steering wheel. The time of contact for the collision between the driver and the steering wheel is approximately 0.10 ms. If the driver wears a seat belt that cannot be stretched, the stopping distance of the driver is the same as the stopping distance of the body of the car. However, if the driver wears a stretchable seat belt, the stopping distance of the driver can be 50% longer than the stopping distance of the car's body. These three possible scenarios are shown in Fig. 5.2.

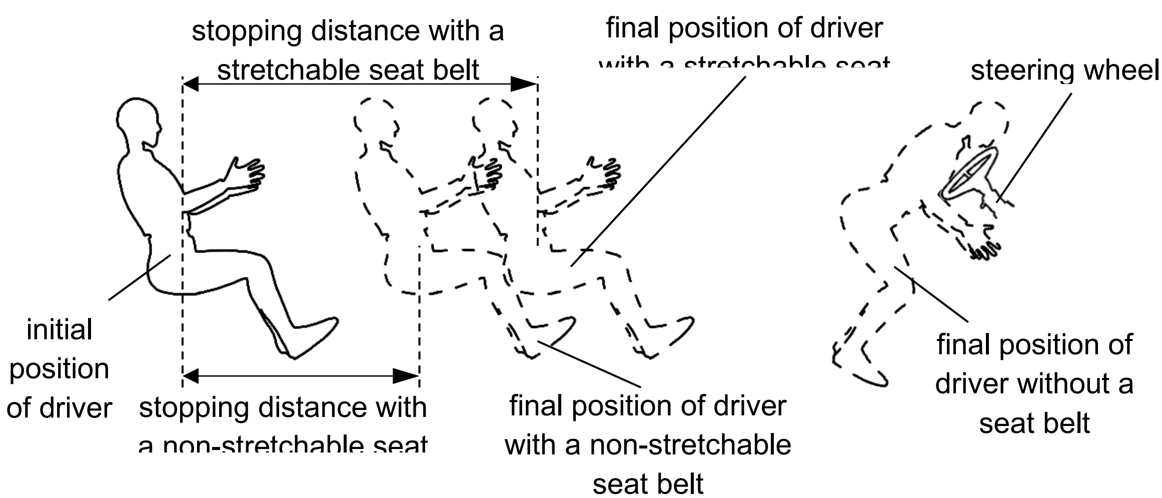

Fig. 5.2

(c) Assuming that the frictional force between the seat and the driver is negligible, explain why the driver will be launched forward after a frontal collision using Newton's first law.

……………………………………………………………………………………………..…….

…………………………………………………...………………...………..... [1]

(d) State the speed of the driver at the instant the car crashes into the barrier.

speed = ……………………… m s^{-1} [1]

(e) Using Newton's second law, determine the force exerted on the driver by the steering wheel when he does not wear a seat belt.

force = ……………………… N [3]

(f) By applying the work-energy theorem, determine the force exerted on the driver by the seat belt when he wears a seat belt that cannot be stretched.

force = ……………………… N [3]

(g) Hence, explain why it is the safest to wear a stretchable seat belt.

…………………………………………………………………………………………..………

…………………………………………………...……………………...……......... [1]

Section B

Answer **Question 6**. There is no choice of question.