futureme
North East Collaborative Outreach Programme

nustem

Car Safety and Stopping Distances

"Potholes are the biggest enemy for road uses and this government is looking at all options to keep our roads in the best condition"
UK Transport Secretary, March 2019.

In Britain, most people's journeys are made by road, and the majority of these are by car or van, so potholes can be a big issue. Potholes can affect the stopping distances of cars, which could lead to accidents.

Velocity, a company based in Sunderland and Newcastle-upon-Tyne, build machines which repair pothole using a process which cleans the road using high-velocity air, then blasts in asphalt. They export the machines internationally.

Image credit: courtesy Velocity UK Ltd.

Road patching using Velocity's system

Know

1. Define each of these terms:
   (i.) stopping distance,
   (ii.) thinking distance, and
   (iii.) braking distance.
2. Write down:
   (i.) two factors which affect the thinking distance, and:
   (ii.) two factors which affect the braking distance.
3. Write down the equation that relates the work done, force, and distance moved.
4. Explain what is meant by the phrase: "Momentum is conserved in a collision"

Apply

5. Suggest how potholes could affect the stopping distance of cars.
6. A car driver has a stopping distance of 60 metres. If the braking distance was 42 metres, what was the thinking distance?
7. Explain why applying the brakes on a car causes the brakes to heat up.
8. A car has a braking distance of 40 metres. The brakes applied a force of 8000 N. Calculate the work done by the brakes to bring the car to a stop.
9. A car has a mass of 1200 kg and is travelling with a momentum of 36000 kg m/s. Calculate the velocity of the car.

Extend

10. A car of mass 1000 kg is travelling with a speed of 12 m/s when it hits a small stationary car of mass 800 kg. After the collision, the two cars are stuck together and move off together. What is the velocity of the two joined cars immediately after the collision?
11. A driver is speeding on the motorway at a speed of 35 m/s when she spots that the road is blocked 100 metres away. Her car has a mass of 1250 kg and a maximum braking force of 6500 N. Deduce if she will be able to stop before she hits the obstruction.

Mark Scheme: Car Safety & Stopping Distances

1.
   - *(i.)* Stopping distance is the distance covered in the time between the driver first spotting a hazard and coming to a stop. Stopping distance = thinking distance + braking distance
   - *(ii.)* Thinking distance is the distance the car / vehicle travels during the driver's reaction time.
   - *(iii.)* Braking distance is the distance the car / vehicle travels from when the brakes are applied to when it stops.
2.
   - *(i.)* Factors affecting thinking distance include initial speed of car and reaction time, which is itself affected by whether driver is tired, whether driver is under influence of drugs and / or alcohol.
   - *(ii.)* Factors affecting braking distance include the initial speed of the car, the condition of the brakes, the condition of the tyres, the road conditions (icy, wet etc,), the weight of the car.
3. Work done (in joules) = Force (in newtons) × distance moved in direction of force (in metres)
   in symbols: $W = Fs$
4. Total momentum before collision = total momentum after collision
5. Pothole could reduce the 'grip' of the tyre on the road due to loose debris. Car would travel further than expected, increasing stopping distance.
6. Thinking distance = Stopping distance − braking distance
   = 60 − 42
   = 18 metres
7. Work done by friction (1) causes transfer from kinetic store (of car) to thermal store (of brakes) (1)
8. $W = Fs$
   = 8000 × 40
   = 320 000 Joules
9. Rearrange: $p = mv$
   $v = \frac{p}{m}$
   = 36 000/1200
   = 30 m/s
10. Calculation to show total momentum before collision = 1000 × 12 = 12 000
    followed by calculation to show velocity after = 12 000/(combined mass of cars)
    = 12 000/(1800)
    = 6.68 m/s
11. Some form of calculation to find distance travelled, for example:
    Re-arrangement to find maximum acceleration: $F = ma$
    $a = F/m$
    = 6500/1250
    = (−)5.2 m s^{-2}
    Distance travelled found by rearrangement: $v^2 = u^2 + 2as$
    $s = \frac{(v^2 - u^2)}{2a}$
    $= \frac{2 - 352}{2 \times 5.2}$
    = 118 m
    So, she will *not* be able to stop in time since 118 > 100.