P8.1 Summary questions

1  a  0.2 s
   b  You can measure reaction time by dropping a ruler that is just above your hand. The distance that is below your hand when you catch it shows your reaction time.
   c  A3, B1, C2

2  a  walking: 1 m/s, sound: 330 m/s, cycling: 6.7 m/s, wind: 13 m/s
   b  acceleration = \frac{\text{change in speed}}{\text{time}}
      = \frac{10 \text{ m/s}}{1.5 \text{ s}}
      = 6.7 \text{ m/s}^2 (2 \text{ sig fig})
   c  Measure distance using tape or trundle wheel, measure time using a light beam.

3  a  Thinking distance: being tired, age, drinking alcohol, using drugs
   Braking distance: condition of the brakes, icy road
   b  change in reaction time = 0.1 s
      30 \text{ mph} = \frac{30 \text{ mph} \times 1609 \text{ m/mile}}{3600 \text{ s/h}}
      = 13 \text{ m/s (2 sig fig)}
      change in thinking distance = \text{speed} \times \text{time}
      = 13 \text{ m/s} \times 0.1 \text{ s} = 1.3 \text{ m}
      70 \text{ mph} = \frac{70 \text{ mph} \times 1609 \text{ m/mile}}{3600 \text{ s/h}}
      = 31 \text{ m/s (2 sig fig)}
      change in thinking distance = \text{speed} \times \text{time}
      = 31 \text{ m/s} \times 0.1 \text{ s} = 3.1 \text{ m}

4  a  16 \text{ mph} = \frac{16 \text{ mph} \times 1609 \text{ m/mile}}{3600 \text{ s/h}}
      = 7.2 \text{ m/s}
      distance = 10 \text{ m (2 sig fig)}
      \left(\text{final velocity (m/s)}\right)^2 - \left(\text{initial velocity (m/s)}\right)^2 = 2 \times \text{acceleration (m/s}^2) \times \text{distance (m)}
      \text{acceleration (m/s}^2) = \frac{\left(\text{final velocity (m/s)}\right)^2 - \left(\text{initial velocity (m/s)}\right)^2}{\text{distance (m)}}
      = \frac{\left(7.2 \text{ m/s}\right)^2 - \left(0 \text{ m/s}\right)^2}{10 \text{ m}}
      = -5.2 \text{ m/s}^2 (2 \text{ sig. fig.})
   b  speed = 160 \text{ mph} = 72 \text{ m/s}
      \left(\text{final velocity (m/s)}\right)^2 - \left(\text{initial velocity (m/s)}\right)^2 = 2 \times \text{acceleration (m/s}^2) \times \text{distance (m)}
      \text{acceleration} = \frac{\left(\text{final velocity (m/s)}\right)^2 - \left(\text{initial velocity (m/s)}\right)^2}{\text{distance (m)}}
      = \frac{\left(72 \text{ m/s}\right)^2 - \left(0 \text{ m/s}\right)^2}{50 \text{ m}}
      = -100 \text{ m/s}^2 (1 \text{ sig fig})
      This is about 20 times as much (10g).
c Everyday accelerations are much smaller than that of either go-kart because cars slow down over a much longer distance.

5 a A large distance gives a much longer distance over which the brakes work, so the acceleration is smaller.

b Large accelerations can cause injury because they decrease blood and oxygen supply to the brain causing blackouts and cause organs to move.

6 a Stopping distance at 30 mph = 23 m, stopping distance at 70 mph = 96 m, nearly 4 times further even though the speed is just over double.

\[ \frac{(0 \text{ m/s})^2 - (22 \text{ m/s})^2}{33 \text{ m}} = -15 \text{ m/s}^2 \text{ (2 sig fig)} \]

b i acceleration =

\[ = -15 \text{ m/s}^2 \]

ii force = mass \times acceleration

= 2000 kg \times 15 \text{ m/s}^2

= 30 000 N

iii speed = 30 mph = 13 m/s
time it takes to stop = 3 seconds

\[ \text{acceleration} = \frac{0 - 13 \text{ m/s}}{3 \text{ s}} \]

= -4.3 m/s^2

mass \times acceleration = force

= 2000 \times 4.3

= 8600 N

7 a It requires a bigger force to stop a more massive object, or a longer time (larger braking distance).

b If they are working long hours it will make them tired which could affect their reaction time (increase it) which means it is more dangerous for them to drive.

c lorry A: force = 30 000 N, mass = 7 tonnes = 7000 kg

\[ \text{force} = \frac{\text{mass}}{\text{acceleration}} \]

\[ = \frac{30 000 \text{ N}}{7000 \text{ kg}} \]

= 4.29 m/s^2
top speed = 70 mph = 31 m/s

\[ \text{braking distance (m)} = \frac{\left( \frac{\text{final velocity (m/s)}}{\text{acceleration (m/s}^2)} \right)^2 - \left( \frac{\text{initial velocity (m/s)}}{\text{acceleration (m/s}^2)} \right)^2}{4.29 \text{ m/s}^2} \]

= \frac{(0 \text{ m/s})^2 - (31 \text{ m/s})^2}{4.29 \text{ m/s}^2}

= 224 m

reaction time = 0.4 s
thinking distance = speed × time = 31 m/s × 0.4 s = 12.4 m
stopping distance = thinking distance + braking distance
= 12.4 m + 224 m
= 236.4 m

lorry B: force = 30 000 N, mass = 8 tonnes = 8000 kg
acceleration = \frac{force}{mass} = \frac{30 000 N}{8 000 kg} = 3.75 \text{ m/s}^2
top speed = 60 \text{ mph} = 26.8 \text{ m/s}
braking distance (m) = \frac{(\text{final velocity (m/s)})^2 - (\text{initial velocity (m/s)})^2}{2 \text{acceleration (m/s}^2\text{)}}
= \frac{(0 \text{ m/s})^2 - (26.8 \text{ m/s})^2}{2 \times 3.75 \text{ m/s}^2}
= 191.5 \text{ m}

reaction time = 0.4 s
thinking distance = speed × time = 26.8 m/s × 0.4 s = 10.7 m
stopping distance = thinking distance + braking distance
= 10.7 m + 191.5 m
= 200 m (1 sig. fig.)

\text{d} The lorry with less mass takes a larger distance to stop. This suggests that the speed limit should be reduced.

\text{e} The stopping distances are significantly increased at these speeds. There is more risk of injury or damage to the car in a collision.