Equations of Motion Worksheet Answers

Q1.

A car starts from rest and accelerates uniformly for 8.0 s. It reaches a final speed of 16 m s^{-1}.

a What is the acceleration of the car?

b What is the average velocity of the car?

c Calculate the distance travelled by the car.

A1.

a $a = \Delta v/\Delta t$
$= (16 - 0)/8.0$
$= 2.0$ m s^{-2}

b average velocity $= (16 + 0)/2$
$= 8.0$ m s^{-1}

c $d = 8.0 \times 8.0 = 64$ m

Q2.

A new model BMW can start from rest and travel 400 m in 16 s.

a What is its average acceleration during this time?

b Calculate the final speed of the car.

c How fast is this final speed in km h^{-1}?

A2.

a $d = V_i t + \frac{1}{2} a t^2$

$400\text{m} = 0 + \frac{1}{2} a(16\text{s})^2$

$a = 800\text{m}/(16\text{s})^2 = 3.1$ m s^{-2}

b $v = v_i + at$
$= 0 + (3.125\text{m/s}^2 \times 16\text{s})$
$= 50$ m/ s

c 50 m s^{-1} = $\frac{50 \times 10^{-3}}{1/3600}$ = 180 km h^{-1}

Q3.

A space-rocket is launched and accelerates uniformly from rest to 160 m s^{-1} in 4.5 s.

a Calculate the acceleration of the rocket.

b How far does the rocket travel in this time?

c What is the final speed of the rocket in km h^{-1}?

A3.

a $v = v_i + at$
$160\text{m/s} = 0 + 4.5\text{s}\ a$

$a = \frac{160}{4.5} = 35.56 = 36$ m s^{-2}

b $d = \left(\frac{vi + vf}{2}\right) t$

$d = \left(\frac{0 + 160}{2}\right) \times 4.5 = 360\,\text{m}$

c $160 \times 3.6 = 576 = 580$ km h^{-1}

Q4.
A diver plunges head first into a diving pool while travelling at 28.2 m s^{-1}. Upon entering the water, the diver stops within a distance of 4.00 m from the diving board. Consider the diver to be a single point located at her centre of mass and assume her acceleration through the water to be uniform.

a Calculate the average acceleration of the diver as she travels through the water.

b How long does the diver take to come to a stop?

c What is the speed of the diver after she has dived for 2.00 m.

A4.

a $v^2 = v_i^2 + 2ad$

$0^2 = (28.2\ \cancel{\text{m/s}})^2 + 2 \times a \times 4.00\text{m}$

$-795.24 = 8a$

$a = -99.4\ \text{m s}^{-2}$

b $d = \left(\frac{vi + vf}{2}\right)t$

$4.00 = \left(\frac{28.2 + 0}{2}\right)t$

$t = \frac{4.00}{14.1} = 0.284\ \text{s}$

c $v^2 = v_i^2 + 2ad$

$= (28.2\ \text{m/s})^2 - 2 \times 99.4\text{m/s}^2 \times 2\text{m}$

$= 397.64$

$v = 19.9\ \text{m s}^{-1}$

Q5.
When does a car have the greatest ability to accelerate and gain speed: when it is moving slowly or when it is travelling fast? Explain.

A5.
Cars have greatest accelerations when they are travelling slowly (i.e. when they are in a low gear). When they are travelling fast, they may have a high speed, but this speed does not increase rapidly when the throttle is pushed.

Q6.
A stone is dropped vertically into a lake. Which one of the following statements best describes the motion of the stone at the instant it enters the water?

A Its velocity and acceleration are both downwards.

B It has an upwards velocity and a downwards acceleration.

C Its velocity and acceleration are both upwards.

D It has a downwards velocity and an upwards acceleration.

A6.
D is the correct answer because the stone is still moving with a downward velocity but is beginning to decelerate which is an acceleration in the opposite direction.

Q7.
A cyclist, whilst overtaking another bike, increases his speed uniformly from 4.2 m s^{-1} to 6.3 m s^{-1} over a time interval of 5.3 s.

a Calculate the acceleration of the cyclist during this time.

b How far does the cyclist travel whilst overtaking?

c What is the average speed of the cyclist during this time?

A7.

a $v_f = v_i + at$

$6.3\text{m/s} = 4.2\text{m/s} + 5.3\text{ s} \times a$

$2.1 = 5.3a$

$a = \dfrac{2.1}{5.3} = 0.396 = +0.40\ \text{m s}^{-2}$

b $d = \left(\dfrac{u+v}{2}\right)t = \left(\dfrac{4.2m/s + 6.3}{2} m/s\right) \times 5.3s = 27.825 = 28\ \text{m}$

c Average speed $= \dfrac{4.2 + 6.3}{2} = 5.25 = 5.3\ \text{m s}^{-1}$

Q8. A car is travelling along a straight road at 75 km h^{-1}. In an attempt to avoid an accident, the motorist has to brake to a sudden stop.

a What is the car's initial speed in m s^{-1}?

b If the reaction time of the motorist is 0.25 s, what distance does the car travel while the driver is reacting to apply the brakes?

c Once the brakes are applied, the car has an acceleration of –6.0 m s^{-2}. How far does the car travel while pulling up?

d What total distance does the car travel from when the driver notices the danger to when the car comes to a stop?

A8.

a 75/3.6 = 21 m s^{-1}

b $d = 21 \times 0.25 = 5.2$ m

c $v_f^2 = v_i^2 + 2ad$

$0 = (21\text{m/s})^2 - (2 \times 6.0\text{m/s})d$

$d = 37$ m

d 37 + 5.2 = 42.2 m

Q9.

A billiard ball rolls from rest down a smooth ramp that is 8.0 m long. The acceleration of the ball is constant at 2.0 m s^{-2}.

a What is the speed of the ball when it is halfway down the ramp?

b What is the final speed of the ball?

c How long does the ball take to roll the first 4.0 m?

d How long does the ball take to travel the final 4.0 m?

A9.

a $v^2 = u^2 + 2ax$

$= 0 + 2(2.0 \times 4.0)$

$v = 4.0\ \text{m s}^{-1}$

b $v^2 = u^2 + 2ax$

$= 0 + 2(2.0 \times 8.0) = 5.7\ \text{m s}^{-1}$

c $v = u + at$

$4.0 = 0 + 2.0\text{t}$

$t = 2.0$ s

d $v = u + at$

$5.657 = 0 + 2.0t$

$t = 2.83$ s

The time to travel final 4.0 m is 2.83 s – 2.0 s = 0.83 s.

Q10.

A cyclist is travelling at a constant speed of 12 m s^{-1} when he passes a stationary bus. The bus starts moving just as the cyclist passes, and accelerates at 1.5 m s^{-2}.

a When does the bus reach the same speed as the cyclist?

b How long does the bus take to catch the cyclist?

c What distance has the cyclist travelled before the bus catches up?

A10.

a $v = u + at$
$12 = 0 + 1.5t$
$t = 8.0$ s

b The bus will catch the cyclist when they have each travelled the same distance from the point where the cyclist first passes the bus.
$12t = 0 + \frac{1}{2}1.5t^2$
$t = 16$ s

c $x = 12 \times 16 = 192$ m