

ANS: Equations of Motion

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Equations of Motion Questions

1. A car moving at a velocity of 25 m/s, accelerates at a rate of 6 m/s². Find its velocity after 3s.

$$v = u + at$$

$$25 + (6 \times 3) = \mathbf{43 \text{ m/s}}$$

2. An object is dropped from rest. Calculate its velocity after 2.5s if it is dropped:

- a. On Earth, where the acceleration due to gravity is 9.8m/s².

$$v = u + at$$

$$0 + (9.8 \times 2.5) = \mathbf{24.5 \text{ m/s}}$$

- b. On Mars, where the acceleration due to gravity is 3.8m/s².

$$v = u + at$$

$$0 + (3.8 \times 2.5) = \mathbf{9.5 \text{ m/s}}$$

3. A motorbike is travelling with a velocity of 3m/s. It accelerates at a rate of 9.3m/s² for 1.8s. Calculate the distance it travels in this time.

$$s = (3 \times 1.8) + \frac{1}{2} \times (9.3 \times 1.8^2)$$

$$= \mathbf{20.5 \text{ m}}$$

4. A Tesla Roadster car accelerates from rest at a rate of 7.1m/s² for a time of 3.9s. Calculate the distance it travels in this time.

$$s = (0 \times 3.9) + \frac{1}{2} \times 7.1 \times 3.9^2$$

$$\mathbf{53.99 \text{ m (round to 54m)}}$$

5. A bullet accelerates at a rate of 90,000m/s² from rest. Calculate its velocity if it travels a distance of 0.5m while accelerating.

$$v^2 = 0 = 0^2 + 2 \times 90,000 \times 0.5 = 90,000$$

$$v = \text{square root}[90,000]$$

$$= \mathbf{300 \text{ m/s}}$$

6. An aircraft is travelling along a runway at a velocity of 25m/s. It accelerates at a rate of 4m/s² for a distance of 750m before taking off. Calculate its take-off speed.

$$v^2 = 25^2 + 2 \times 4 \times 750 = 6625$$

$$v = \text{square root } \{6625\}$$

$$= \mathbf{81.4 \text{ m/s}}$$

7. A car is travelling at a speed of 21m/s. It accelerates at an average rate of 3m/s² for a time of 4 seconds. Find the distance it travels.

$$s = (21 \times 4) + \left(\frac{1}{2} \times 3 \times 4^2\right)$$

$$= \mathbf{108 \text{ m}}$$

8. A car accelerates at a rate of 10m/s² for a time of 4s. It reaches a speed of 52 m/s. Calculate its initial speed.

$$u = v - at$$

$$u = 52 - (10 \times 4)$$

$$= \mathbf{12 \text{ m/s}}$$

9. A bullet is at rest. It travels a distance of 0.34m in a time of 0.0095 seconds. Calculate its acceleration.

$$a = \frac{2d}{t^2}$$

$$(2 \times 0.34) / 0.0095^2$$

$$= 7534.626 \text{ m/s}^2$$

10. A falcon is diving at a speed of 30m/s. It accelerates at a rate of 40m/s² and reaches a speed of 100m/s. Calculate the distance it travels during its acceleration.

$$v^2 = u^2 + 2as$$

$$s = \frac{v^2 - u^2}{2a}$$

$$100^2 - 30^2 / 2 \times 40$$

$$= 113.75 \text{ m}$$

11. A snail is at rest. It accelerates at a rate of 0.00075m/s². Calculate the time it takes to reach a speed of 0.0135m/s.

$$t = v/a$$

$$0.0135 / 0.00075$$

$$= 18 \text{ s}$$

12. A blue shark accelerates at a rate of 16m/s² for a time of 0.8s. During this time it travels a distance of 11.52m. Calculate its initial speed.

$$\text{1st: } s = ut + \frac{1}{2} at^2$$

$$\text{2nd: } s - \frac{1}{2} at^2 = ut$$

$$\text{3rd: } u = \frac{s - \frac{1}{2} at^2}{t}$$

$$11.52 - (\frac{1}{2} \times 16 \times 0.8^2) / 0.8$$

$$= 8 \text{ m/s}$$

13. A car is travelling at a speed of 30m/s. It **decelerates** at a rate of 12m/s². Calculate the time taken for the car to come to rest.

$$v = u + at$$

$$t = u/a$$

$$-30 / -12 \text{ (-due to deceleration-cancel each other so answer becomes a positive)}$$

$$= 2.5 \text{ s}$$

14. A stone is thrown vertically **upwards**. It decelerates at a rate of 9.8m/s². It reaches a **greatest height of 16.53m**. Calculate its initial speed.

$$v = u^2 + 2as$$

$$U^2 = -2as$$

$$-2 \times -9.8 \text{ (- as opposing motion)} \times 16.53 = 323.53$$

$$u = \sqrt{323.53}$$

$$= 18 \text{ m/s}$$

15. A rubber toy pops up to a **maximum height** of 2.51m. Find its initial velocity.

$$v = u^2 + 2as$$

$$U^2 = -2as$$

$$-2 \times -9.8 \times 2.51 = 49.16$$

$$\sqrt{49.16}$$

$$= 7 \text{ m/s}$$

More Equation of Motion problems

1. An airplane accelerates down a runway at 3.20m/s² for 32.8s until it finally lifts off the ground. Determine the distance travelled before take off.

$$s = ut + \frac{1}{2} at^2$$

Initial v is 0, therefore:

$$s = \frac{1}{2} at^2$$

$$\frac{1}{2} \times 3.2 \times 32.8^2$$

$$= 1732 \text{ m}$$

$$=1722\text{m}$$

2. A race car accelerates uniformly from 18.5m/s to 46.1m/s in 2.47 seconds. Determine the acceleration of the car and the distance travelled.

$$a=v-u/t$$

$$46.1-18.5/2.47=11.2$$

Therefore:

$$s=ut + 1/2at^2$$

$$(18.5 \times 2.47) + (1/2 \times 11.2 \times 2.47^2)$$

$$=80\text{m}$$

3. A feather is **dropped** on the moon from a height of 1.40 metres. The acceleration of gravity on the moon is 1.67m/s². Determine the time for the feather to fall to the surface of the moon.

$$\text{Use } s=ut + 1/2at^2$$

Can eliminate ut part of equation as u=0

$$\text{Left with } s=1/2at^2$$

Need to find t so:

$$t= \text{square root } \{2s/a\}$$

$$=1.29\text{s}$$

4. A bullet leaves a rifle with a muzzle velocity of 521m/s. While accelerating through the barrel of the rifle, the bullet moves a distance of 0.840m. Determine the acceleration of the bullet (assume a uniform acceleration).

$$\text{Use } v^2=u^2 + 2as$$

$$a= v^2 - u^2/2s$$

$$a= 521^2 - 0^2/2 \times 0.840$$

$$=161,572\text{m/s/s}$$

5. An engineer is designing a runway for an airport. Several planes will use the runway and the engineer must design it so that it is long enough for the largest planes to become airborne before the runway ends. If the largest plane accelerates at 3.30m/s² and has a takeoff speed of 88.0m/s, then what is the minimum allowed length for the runway?

$$v^2=u^2 + 2as$$

u=0 so remove from equation

$$v^2=2as$$

Need to find s therefore $s=v^2/2a$

$$(88^2)/(2 \times 3.30)$$

$$=1170 \text{ m (rounded to 3 significant figures)}$$

6. A student drives 4.8km to school and averages a speed of 22.6m/s. On the return trip home, the student travels with an average speed of 16.8m/s over the same distance. What is the average speed (in m/s) of the student for the two-way trip? (Be careful, its not as simple as finding the average between the two speeds. Hint: find the total time for the round trip)

Find total distance (in m!!)

$$4800 \times 2 = 9600\text{m}$$

Find time 1:

$$T^1=d/s$$

$$4800/22.6=212.39$$

Find time 2:

$$T^2= 4800/16.8$$

$$=285.71$$

$$\text{Total time}= 212.39 + 285.71=498.10$$

$$t=d/t$$

$$9600/498.10$$

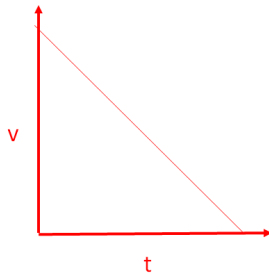
$$=19.4\text{m/s}$$

7. Rennata Gas is driving through town at 25.0m/s and begins to accelerate at a constant rate of -1.0 m/s². Eventually Rennata comes to a complete stop. Represent Rennata's accelerated motion by sketching a velocity-time graph. Use the equations of motion to calculate the distance which Rennata travels while decelerating. Then use the velocity time graph to determine this distance.

$$\text{Use } v^2=u^2 + 2as$$

Find s ($s = \frac{v^2 - u^2}{2a}$)
 $s = \frac{0^2 - 25^2}{2 \times -1}$
 $s = \frac{-625}{-2}$
= 312.5m

The v-t graph should look like this:



8. Otto Emissions is driving his car 25.0m/s. Otto accelerates at 2.0m/s² for 5 seconds. Otto then maintains a constant velocity for 10 more seconds. Determine the distance which Otto travelled during the entire 15 seconds. (Consider using a velocity-time graph)

Must properly draw graph and then determining area under graph

1st= find v

$$v = u + at = 35\text{m/s}$$

2nd: calculate area under graph (square (w x h) then triangle ($\frac{1}{2} \times w \times h$))

=500m

9. ~~Chuck Wagon travels with a constant velocity of 0.5mile/minute for 10 minutes. Chuck then decelerates at $-0.25\text{mile}/\text{min}^2$ for 2 minutes. Determine the total distance travelled by Chuck Wagon during the 12 minutes of motion. (Consider using a velocity time graph)~~

=5.5 miles OR 8.8km OR 8851.4m