Problems for chapter 3.

Summary: Speed is the slope of the s vs. t graph

Acceleration is the slope of the v vs. t graph.

The change in speed is the area under the a vs. t graph.

The distance covered is the area under the v vs. t graph.

$s - s_0 = vt$ constant speed

$v - v_0 = at$ constant acceleration

$s - s_0 = \frac{v + v_0}{t} = v_0 t + \frac{1}{2}at^2$ constant acceleration

$v^2 = v_0^2 + 2a(s - s_0)$ constant acceleration

$$v = \frac{2\pi r}{T} = \omega r$$

$$a = \omega^2 r = \frac{v^2}{r}$$

$$r_x = r\cos\omega t \;,\; r_y = r\sin\omega t$$

$$v_x = -\omega r\sin\omega t \;,\; v_y = \omega r\cos\omega t$$

$$a_x = -\omega^2 r\cos\omega t = -\omega^2 r_x$$

$$a_y = -\omega^2 r\sin\omega t = -\omega^2 r_y$$

1.* One mile was equal to 1.609 km. Convert an old speed of 20.0 miles per hour to the now current speed in kilometres per hour. Now convert this speed to the familiar units of m s^{-1}.

2. The old open road speed limit was once 50 miles per hour, what is this speed in kilometres per hour, and m s^{-1}? (Use the information in question 1.)

3.* What is the average value of the following speeds? 10.0 m s^{-1}, 11.5 m s^{-1}, 13.0 m s^{-1}, 14.5 m s^{-1}, 16.0 m s^{-1} and 17.5 m s^{-1}. Assume that these speeds are measured every two seconds, starting from $t = 0$ and plot these speeds on a graph and determine values of a and v_0 for the equation $v = at + v_0$.

4. What is the average value of the following speeds? 22.25 m s^{-1}, 24.00 m s^{-1}, 26.75 m s^{-1}, 29.50 m s^{-1}, 31.25 m s^{-1} and 33.00 m s^{-1}. Assume that these speeds are measured every three seconds, starting from $t = 0$ and plot these speeds on a graph and determine values of a and v_0 for the equation $v = at + v_0$.

5.* The distance an object moves (along a straight line) with time is given as {(t s,s m):(0,10.0),(0.5,12.0),(1,14.0),(1.5,16.0),(2.0,18.0),(3.0,22.0)}. Determine the speed and acceleration of the object.

6. The distance s an object moves (along a straight line) with time t is given by {(t s,s m):(0,11.0),(1.0,13.0),(2.0,15.2),(3.0,17.5),(4.0,20.0),(5.0,22.7)}. Estimate the speed and acceleration of the object at each of the given times.

7.* Go back to the data in question 3. and determine the distance that a car might travel if it was moving with the given speeds each two seconds.

8. Go back to the data in question 4. and determine the distance that a car might travel if it was moving with the given speeds each three seconds.

9.* A falling object accelerates downwards with a constant acceleration of 9.80 m s^{-2}. If the object starts falling from rest find its speed and the total distance through which it has fallen for the first second using 0.10 s intervals.

10. A falling object accelerates downwards with a constant acceleration of 9.80 m s^{-2}. If the object starts falling with a downward speed of 2.0 m s^{-1}, find its speed and the total distance through which it has fallen for the first second using 0.10 s intervals.

11.* A "world class" male athlete can run 100.0 m in 10.00 s and 200.0 m in 19.60 s. Does he run faster for the 200 m? What is the average speed for each case? What are the speeds in terms of street speeds in km hr^{-1}? If the athlete accelerates with an average acceleration of 20 m s^{-2} estimate the time and distance over which he accelerates.

12. A "world class" female athlete can run 100.0 m in 11.00 s and 200.0 m in 21.80 s. Does she run faster for the 200 m? What is the average speed for each case? What are the speeds in terms of street speeds in km hr^{-1}? If the athlete accelerates with an average acceleration of 20 m s^{-2} estimate the time and distance over which she accelerates.

13.* A car with good brakes and tyres can decelerate at about "1g" or -9.8 m s^{-2}, before the tyres start slipping (or skidding). Under hard acceleration the wheels will also just start to skid and this suggests that a car in good condition can also accelerate at about 10 m s^{-2}. Find the speed and distance travelled for a car that manages this maximum acceleration for 2.0 s. If the car covers 400 m, from rest in 14.0 s what are the average speed and acceleration?

14. A car with compound tyres can decelerate at about "2g" or -19.6 m s^{-2}, before the tyres start slipping (or skidding). Under hard acceleration the wheels will also just start to skid and this suggests that a race car can accelerate at about 20 m s^{-2}. Find the speed and distance travelled for a car that manages this maximum acceleration for 2.0 s. If the car covers 400 m, from rest in 10.0 s what are the average speed and acceleration?

15.*A hammer thrower releases the ball at the end of the hammer with a speed of 35.0 m s^{-1}. If the ball is 2.10 m from the axis about which her body turns, how many times will she turn in 1.0 s if she continues to turn at this rate?

16. A discus thrower releases the disc with a speed of 25.0 m s^{-1}. If this disc is 1.20 m from the axis about which his body turns, how many times will he turn in 1.2 s if he continues to turn at this rate?

17.* The tyres of a car (see question 13.) can prevent sideways acceleration of up to 8.00 m s^{-2}. If this car turns a corner at 60 km hr^{-1} what is the smallest radius of curvature about which it can turn without skidding? (Don't mix your units of speed.)

18. The tyres of a car (see question 14.) can prevent sideways acceleration of up to 15.00 m s^{-2}. If this car turns a corner at 80 km hr^{-1} what is the smallest radius of curvature about which it can turn without skidding? (Don't mix your units of speed.)

19.*Show that you cannot use the equation $v = v_0 + at$ when describing harmonic motion. If an equation for harmonic motion is $x - 2.0 = 0.25\cos(0.11t)$ m where ω = 0.11 radian s^{-1}, find values of the maximum magnitude of acceleration and speed for this motion.

20. Show that you cannot use the equation $v = v_0 + at$ when describing rotational motion, where $a = \frac{v^2}{R}$, with R the radius of the circle. If for circular motion the radius is 2.5 m, the period is T = 1.10 s, find the tangential speed and radial acceleration a.