Physics for Engineers **T2 solutions**

Chapter 2: Understanding Kinetic Forces

1. Briefly explain kinetics and uniform motion. (answers at the bottom of the page)
2. Draw distance-time graph to illustrate uniform and non-uniform motions. Fig 2.1 of chapter 2 notes.
3. Convert 150 m/s into km/hr. $\frac{150}{1000}$ km / $\frac{1}{3600}$ hr = 540 km/hr.
4. Figure 2.4 shows how John travels. Briefly, describe Figure 2.4. What can you deduced from it?

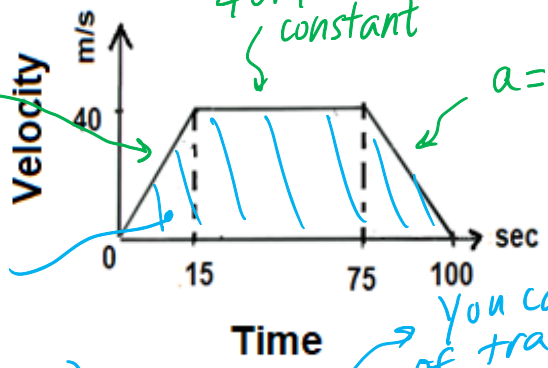


Figure 2.4

$a = \frac{40}{15}$ m/s² $= \frac{8}{3}$ m/s²

40 m/s constant

$a = \frac{(0-40)\text{ m/s}}{(100-75)\text{ s}} = -\frac{40}{25}$ m/s² $= -\frac{8}{5}$ m/s²

distance covered by John is $(\frac{1}{2}\times 15\times 40) + (60\times 40) + (\frac{1}{2}\times 25\times 40) = 3200$ m or 3.2 km

You can also use the area of trapezoid formula

Area $= \frac{1}{2}(60+100)\,40$ m $= 3200$ m $= 3.2$ km

5. A car travelled 10 m in 5 seconds in the x-direction. The driver made a U-turn and travelled 20 m to B in 11 seconds. (See Figure 2.5). Find the average speed and velocity.

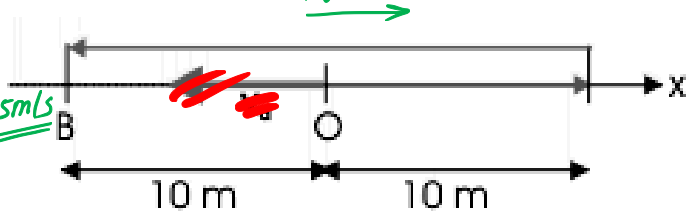


Figure 2.5

Total distance $= 10 + 20 = 30$ m

Avg speed $= \frac{30\text{ m}}{(5+11)\text{ s}} = 1.875$ m/s

Total displacement $= -10$ m

$\therefore$ Avg velocity $= -\frac{10\text{ m}}{16\text{ s}} = -0.625$ m/s

Q1 Answers

Dynamics is that branch of mechanics which deals with the motion of bodies under the action of forces. Dynamics has 2 distinct parts, kinematics and kinetics. *Kinematics* is the study of motion without reference to the forces which cause motion. ***Kinetics*** - is the study of motion of bodies under the influence of forces acting on them. ***Uniform motion*** - When a body moves along a straight line without changing its speed, it is said to be in uniform motion.

6. Figure 2.6 shows a bike ride by Mary.

   a) How long was Mary stationary?
   b) What was the total distance travelled by Mary?
   c) What was her average speed in kilometres per hour between 17:15 and 17:45?

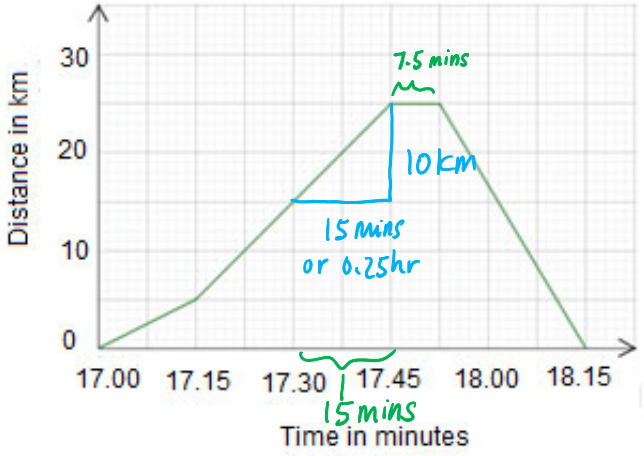


Figure 2.6

7. Figure 2.7 shows a distance-time graph describing a 1500m race ran by Adam. Work out the speeds for the three distance travelled. What is the maximum and the lowest speeds reached in this run. Give your answer to three significant figure.

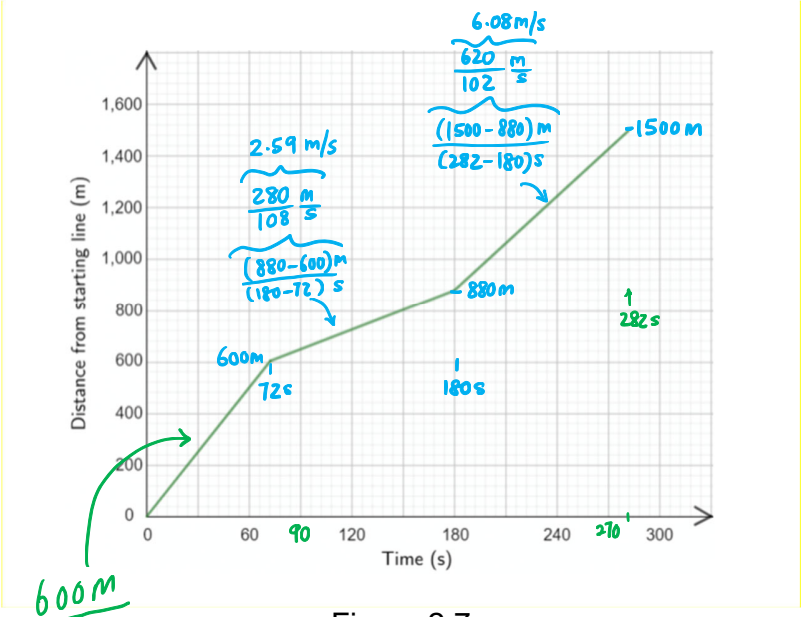


Figure 2.7

$a = \frac{40\ m/s}{20\ s} = 2\ m/s^2$ //

8. A car accelerates from rest to 40 m/s in 20 seconds. Determine the car's acceleration. The car then decelerates for 15 seconds and stopped. What is the rate of deceleration?

$a = -\frac{40\ m/s}{15\ s} = -2.67\ m/s^2$ //

Recall
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 - u^2 = 2as$

9. A car starts at rest and accelerates constantly at 5 m/s² in 1 second. Determine (a) the car speed and (b) the distance after 10 seconds.

$u = 0$ (a) (t)

$v = u + at = 5\ m/s$ //

(t) $s = ut + \frac{1}{2}at^2 = \frac{1}{2} \times 5 \times 10^2 = 250\ m$ //

10. A car travels at a constant speed of 60 m/s, and then decelerates at 5 m/s² until rest. Determine time elapsed and car's distance before rest.

$v = u + at$ (0, 60, −5)

$t = \frac{60}{5}\ s = 12\ s$ //

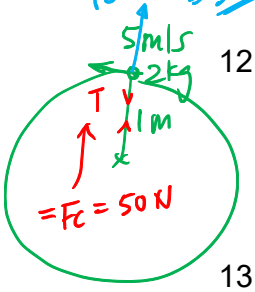
$v = 0$ (t) $u = 60\ m/s$ (s) $a = -5\ m/s^2$

$v^2 - u^2 = 2as \Rightarrow s = \frac{60^2}{2 \times 5} = 360\ m$ //

11. A car speeding at 110 km/hr past a police car on a roadside. One minute later, the police car chases at 1m/s². How far did the police car go before reaching the car? Calculate the time taken by the police car to catch up the speeding car?

Solutions on next page.

centripetal force $F_c = \frac{mv^2}{r} = \frac{2 \times 5^2}{1} = 50N$



12. A 2kg ball attached to a 1.0m string moves in a horizontal uniform circular motion at speed of 5 m/s. What is the acceleration of the ball and the centripetal force acting on the ball?

$a = \frac{v^2}{r} = \frac{5^2}{1} = 25\ m/s^2$ //

This is provided by T which is 50N // tension in the string

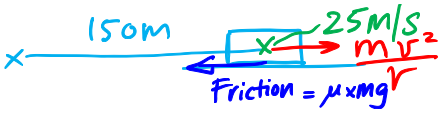
13. John attached a 2kg ball to a 2m long string. He swings the ball in a uniform circular motion and the taut string is experiencing a 90 N force. Calculate the maximum speed the ball can travel without breaking the string.

Assume $T_{max} = 90N$, $\frac{mv^2}{r} = 90 \Rightarrow \frac{2 \times v^2}{2} = 90 \Rightarrow v^2 = 90$

$v = \sqrt{90}$ or $9.5\ m/s$ //

maximum

14. A car ~~moves~~ can navigate around a uniform circular path of radius 150m at a velocity of 25 m/s. What is the coefficient of friction between the car and the road?



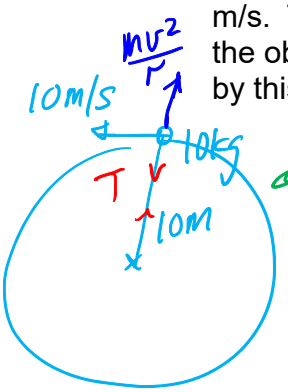
$\frac{mv^2}{r} = \frac{m \times 25^2}{150}\ N$

$\mu mg = \frac{m \times 25^2}{150}$

$\mu = \frac{25^2}{150 \times 9.8} = 0.425$ //

Note: μ has no dimensional unit as it is a ratio of 2 forces.

15. A 10 kg object is circulating in a uniform circulator motion with a speed of 10 m/s. The diameter of the circulator motion is 20m. How long does it takes for the object to make one revolution? What is the centripetal force experienced by this object? What is the object's angular velocity?



circumference $C = 2\pi \times 10 = 20\pi\ m$

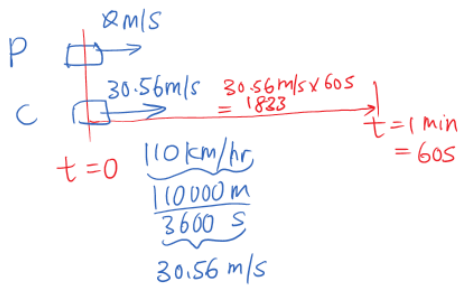
∴ one cycle takes $\frac{20\pi\ m}{10\ m/s} = 2\pi\ s$ or $6.28\ s$ //

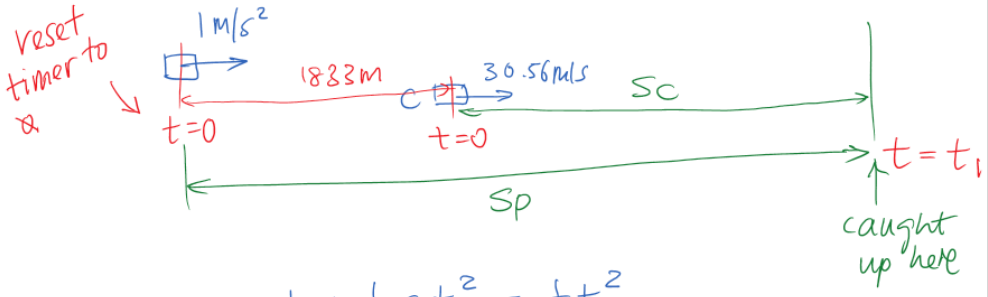
$f = \frac{1}{T} = \frac{1}{2\pi}\ Hz \Rightarrow \omega = 2\pi f = 2\pi \times \frac{1}{2\pi} = 1\ rads^{-1}$ //

Centripetal force is provided by the tension T.

$T = \frac{mv^2}{r} = \frac{10 \times 10^2}{10} = 100\ N$ //

Q11





$$S_p = \underset{\int}{u}\underset{0}{t} + \tfrac{1}{2}\underset{\int}{a}\underset{1}{t_1^2} = \tfrac{1}{2}t_1^2$$

$(1833 + S_c)$

$$S_c = 30.56 \times t_1$$

$$\therefore \quad 1833 + 30.56t_1 = \tfrac{1}{2}t_1^2$$

$$t_1^2 - 61.1t_1 - 3666 = 0$$

solved with calculator $t_1 = 98.4\,s, \cancel{-37.3\,s}$

$$S_p = \tfrac{1}{2} \times 98.4^2 = 4841\,m \text{ or } 4.84\,km //$$

The police caught up with the passing car (1 min + 98.4 s) after the car passed the police car.