14.16 The displacement time graph of a particle executing S.H.M. is shown in Fig. 14.5. Which of the following statement is/are true?

(a) The force is zero at $t = \frac{3T}{4}$.

(b) The acceleration is maximum at $t = \frac{4T}{4}$.

(c) The velocity is maximum at $t = \frac{T}{4}$.

(d) The P.E. is equal to K.E. of oscillation at $t = \frac{T}{2}$.

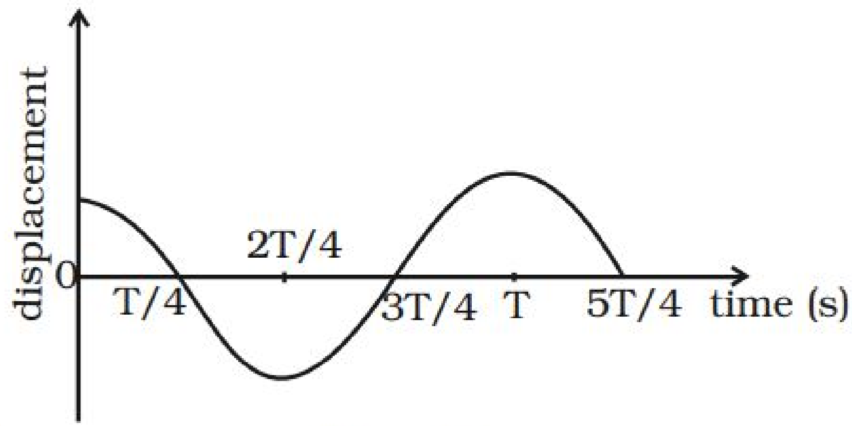


Fig.14.5

NCERT EXEMPLAR

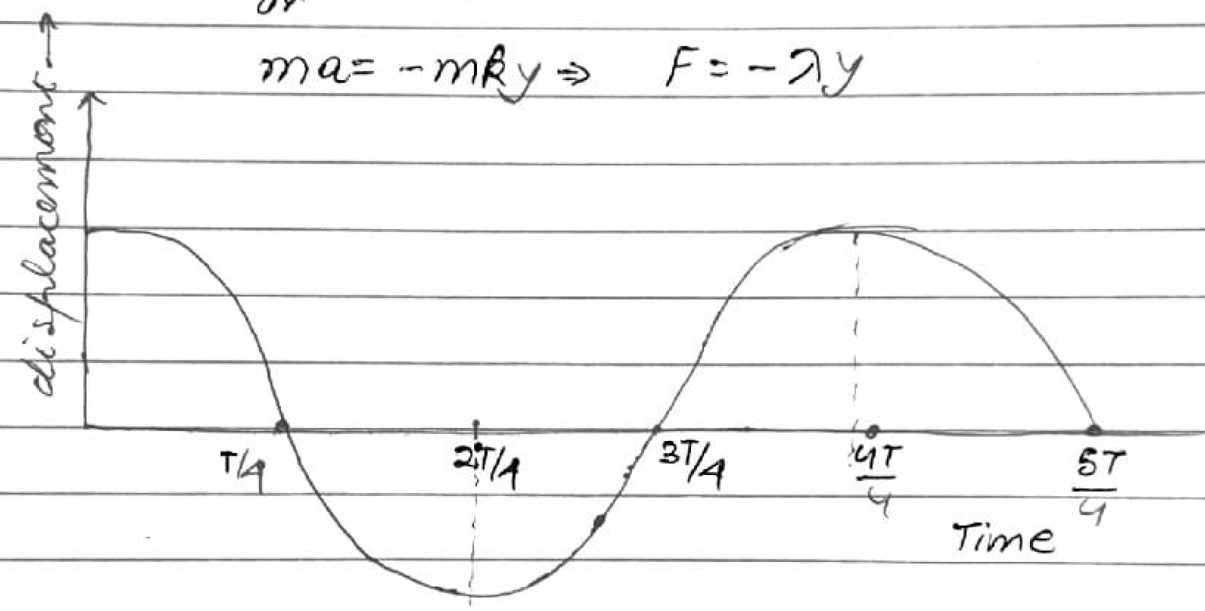
SOLUTION:

Particle is executing SHM, so

$$a = -ky$$

or

$$ma = -mky \Rightarrow F = -\lambda y$$



(a) The force is zero at $t = \frac{3T}{4}$ — (TRUE)

So, at $t = \frac{3T}{4}$, displacement = 0, i.e particle is at mean position.

Now further $F = -\lambda y$ and $y = 0$ so '$F = 0$'

(b) The acceleration is max at $t = \frac{4T}{4}$ — (TRUE)

In SHM, acceleration is max at extreme positions. and also $a = -ky$, so when 'y' is max, 'a' is max.

At $t = \frac{4T}{4}$, we have $y \equiv$ max, so 'a' should be max.

(c) The velocity is max at $t = \frac{T}{4}$ — (TRUE)

The velocity is max at mean position, as force at mean position is zero.

and also $v = \omega\sqrt{A^2 - x^2}$

$V_{max} = \omega A$ when $x = 0 \Rightarrow$ mean position.

so, at $t = \frac{T}{4}$, we have displacement to be zero, so, it is at mean position.

(d) THE P.E = K.E at $t = \frac{T}{2}$ — (FALSE)

$P.E = \frac{1}{2}Kx^2$ AND $K.E = \frac{1}{2}mv^2 = \frac{1}{2}m\left[\omega\sqrt{A^2 - x^2}\right]^2$

$= \frac{1}{2}m\omega^2(A^2 - x^2)$

so, for PE = KE

$\frac{1}{2}\cancel{K}x^2 = \frac{1}{2}\cancel{m\omega^2}(A^2 - x^2)$ since $\omega^2 = \frac{K}{m} \Rightarrow m\omega^2 = K$

$x^2 = A^2 - x^2 \Rightarrow \left(x = \pm\frac{A}{\sqrt{2}}\right)$

but at $t = \frac{T}{2}$, we have $(x = -A)$, so the statement is false.

Finally correct answers are (a), (b), (c).