Physicsaholics

DPP – 1 (Circular Motion)

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Q 1. The angular velocity of a particle is given by $\omega = 1.5t - 3t^2 + 2$, Find the time when its angular acceleration becomes zero:
(a) 0.25 sec (b) 0.5 sec
(c) 1 sec (d) 2 sec

Q 2. A wheel rotates with an angular acceleration given by $\alpha = 4at^3 - 3bt^2$, where t is the time and a and b are constants. If the wheel has initial angular speed ω_0, write the equations for the angular speed:
(a) $\omega = \omega_0 + 4at^4 - 3bt^3$ (b) $\omega = \omega_0 + at^4 - bt^3$
(c) $\omega = at^4 - bt^3$ (d) $\omega = 4at^4 - 3bt^3$

Q 3. A grinding wheel attained a velocity of 20 rad/sec in 5 sec starting from rest. Find the number of revolutions made by the wheel.
(a) $\pi/25$ revolutions (b) $1/\pi$ revolutions
(c) $25/\pi$ revolutions (d) none of these

Q 4. The magnitude of displacement of a particle moving in a circle of radius with a constant angular speed ω varies with time t as:
(a) 2 a sin ωt (b) 2a sin (ωt /2)
(c) 2a cos ωt (d) 2a cos (ωt /2)

Q 5. The ratio of angular speeds of minutes hand and hour hand of a watch is -
(a) 1 : 12 (b) 6 : 1
(c) 12 : 1 (d) 1 : 6

Q 6. The angular displacement of a particle is given by $\theta = (t^3 + t^2 + t + 1)$ rad then, its angular velocity (in rad/s) at t = 2 sec is:
(a) 27 (b) 17
(c) 15 (d) 16

Q 7. The angular displacement of a particle performing circular motion is $\theta = \left(\frac{t^3}{60} - \frac{t}{4}\right)$ where θ is in radian and 't' is in second .Then the angular velocity and angular acceleration of particle at the end of 5 s will be:
(a) 1 rad/s, 5 rad/s^2 (b) 1 rad/s, 0.5 rad/s^2
(c) 5 rad/s, 1 rad/s^2 (d) 0.1 rad/s, 5 rad/s^2

Q 8. What is the angular acceleration of a particle if the angular velocity of a particle becomes 4 times of its initial angular velocity 1 rad/s in 2 seconds:
(a) 0.5 rad/s^2 (b) 1 rad/s^2

(c) 1.5 rad/s^2 (d) 2 rad/s^2

Q 9. A fan is rotating with angular velocity 100 rev/s. Then it switched off. It takes 5 min to stop. Find the total number of revolution made before the fan stops: (assume uniform angular retardation)

(a) 9000 rev (b) 13000 rev

(c) 15000 rev (d) 4500 rev

Q 10. The angular acceleration of a fan is $\alpha = -\frac{3}{2}t^2$. At the initial moment, its angular velocity ω = 10 rad/s and has an angular position of 1 rad. Choose the incorrect option:

(a) its angular velocity at t=1sec. is 9.5 rad/s

(b) its angular position at t=2 sec. is 5 rad

(c) its angular velocity at t=2 sec. is 6 rad/s

(d) its angular position at t=1 sec. is $\frac{87}{8}$ rad

Answer Key

Q.1 a	**Q.2 b**	**Q.3 c**	**Q.4 b**	**Q.5 c**
Q.6 b	**Q.7 b**	**Q.8 c**	**Q.9 c**	**Q.10 b**

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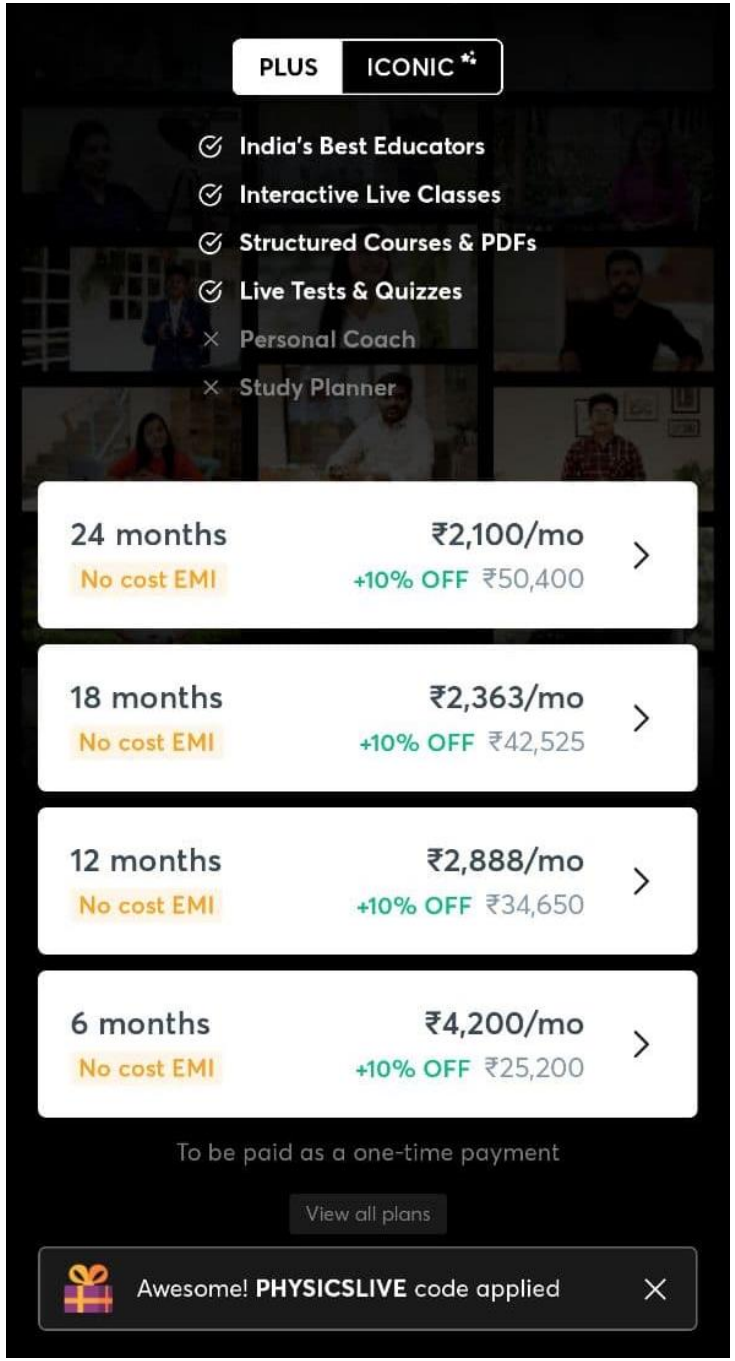


Written Solution

DPP-1 Angular displacement, velocity and angular acceleration and kinematics of circular motion

By Physicsaholics Team

Solution: 1

$$\omega = 1.5t - 3t^2 + 2$$

$$\alpha = \frac{d\omega}{dt} = 1.5 - 6t = 0$$

$$t = \frac{1.5}{6} = \frac{3}{2 \times 6} = \frac{1}{4}$$

$$\boxed{t = 0.25 \text{ sec}}$$

Ans. a

Solution: 2

$$\alpha = 4at^3 - 3bt^2$$

$$\frac{d\omega}{dt} = 4at^3 - 3bt^2$$

$$\int_{\omega_0}^{\omega} d\omega = \int_0^t (4at^3 - 3bt^2)\,dt$$

$$\omega - \omega_0 = \left(\frac{4at^4}{4} - \frac{3bt^3}{3}\right)_0^t$$

$$\boxed{\omega = \omega_0 + at^4 - bt^3}$$

Ans. b

Solution: 3

$$\omega = \omega_0 + \alpha t$$

$$20 = 0 + \alpha(5)$$

$$\boxed{\alpha = 4\ \text{rad/s}^2}$$

Now

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\theta = 0 + \frac{1}{2} \times 4 \times (5)^2 = 50\ \text{rad.}$$

(n) no. of revolutions $= \frac{\theta}{2\pi}$

$$n = \frac{50}{2\pi}$$

$$\boxed{n = \frac{25}{\pi}}$$

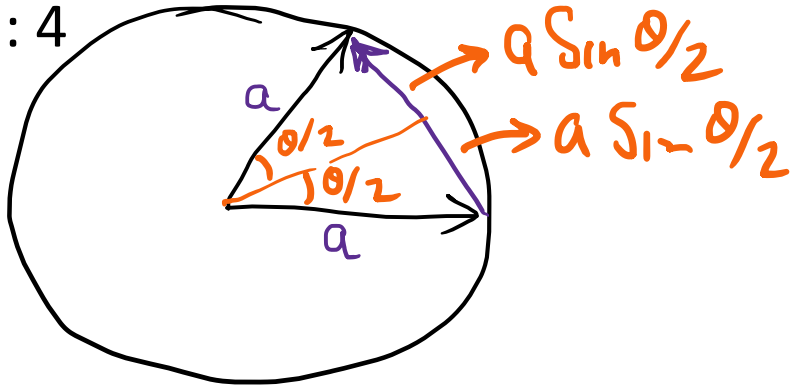
OR

$$\theta = \frac{\omega + \omega_0}{2} \times t$$

$$= \frac{20+0}{2} \times 5 = 50\ \text{rad}$$

Ans. c

Solution: 4



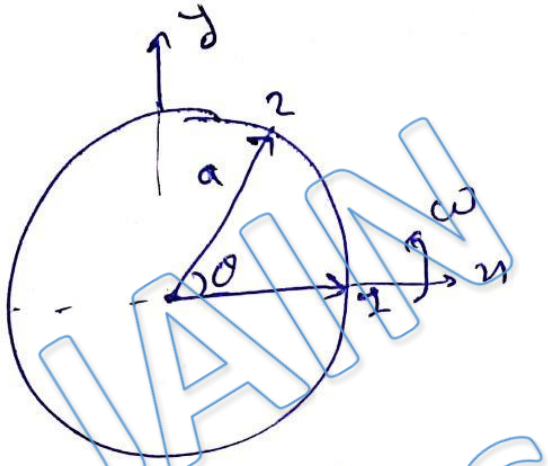
Displacement after rotating by angle θ

$$|\overrightarrow{\Delta r}| = 2a \sin\theta/2$$

Since $\theta = \omega t$

$$|\overrightarrow{\Delta r}| = 2a \sin\left(\frac{\omega t}{2}\right)$$

(08)



$\vec{r_1} = a\hat{i}$

$\vec{r_2} = a\cos\theta\hat{i} + a\sin\theta\hat{j}$

displacement, $\vec{s} = \vec{r_2} - \vec{r_1}$

$= (a\cos\theta - a)\hat{i} + a\sin\theta\hat{j}$

$s = |\vec{s}| = \sqrt{(a(\cos\theta - 1))^2 + (a\sin\theta)^2}$

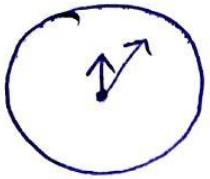
$s = 2a\sin\frac{\theta}{2}$

$\because \theta = \omega t$

$$\boxed{s = 2a\sin\frac{\omega t}{2}}$$

Ans. b

Solution: 5



(i) for minute hand

Time taken to complete one revolution = 60 min
= 3600 sec

$$\omega_1 = \frac{2\pi}{3600} = \frac{\pi}{1800} \text{ rad/sec}$$

(ii) for hour hand

Time taken to complete one revolution = 12 hr
= 12 × 60 min
= 12 × 60 × 60 sec
= 12 × 3600 sec

$$\omega_2 = \frac{2\pi}{12 \times 3600} \text{ sec} = \frac{\pi}{12 \times 1800} \text{ sec}$$

$$\therefore \frac{\omega_1}{\omega_2} = \frac{\frac{\pi}{1800}}{\frac{\pi}{12 \times 1800}} = \frac{12}{1}$$

$$\boxed{\frac{\omega_1}{\omega_2} = \frac{12}{1}}$$

OR

$$\frac{\omega_{min}}{\omega_{hr}} = \frac{T_{hr}}{T_{min}}$$

$$= \frac{12 \text{ hr}}{1 \text{ hr}} = \frac{12}{1}$$

Ans. c

Solution: 6

$$\theta = t^3 + t^2 + t + 1$$

$$\omega = \frac{d\theta}{dt} = 3t^2 + 2t + 1$$

$$\omega = 3t^2 + 2t + 1$$

at $t = 2\ sec$

$$\omega = 3(2)^2 + 2(2) + 1$$

$$\boxed{\omega = 17\ rad/sec}$$

Ans. b

Solution: 7

$$\theta = \frac{t^3}{60} - \frac{t}{4}$$

$$\omega = \frac{3t^2}{60} - \frac{1}{4} = \frac{t^2}{20} - \frac{1}{4} \text{ rad/sec}$$

$$\omega_{t=5} = \frac{(5)^2}{20} - \frac{1}{4} = \frac{25}{20} - \frac{1}{4} = \frac{5}{4} - \frac{1}{4}$$

$$\boxed{\omega_{t=5} = 1 \text{ rad/s}}$$

(E) $$\alpha = \frac{d\omega}{dt} = \frac{2t}{20} \quad \text{--- (1)}$$

$$\alpha = \frac{t}{10} \text{ rad/s}^2$$

$$\alpha_{t=5} = \frac{5}{10} = \frac{1}{2}$$

$$\boxed{\alpha_{t=5} = 0.5 \text{ rad/s}^2}$$

Ans. b

Solution: 8

$\omega_0 = 1 \text{ rad/sec}$

$\omega = 4\omega_0 = 4 \text{ rad/sec.}$

$\omega = \omega_0 + \alpha t$

~~$4\omega_0$~~

$4 = 1 + \alpha(2)$

$\alpha = 3/2 \text{ rad/s}^2$

$\alpha = 1.5 \text{ rad/s}^2$

Ans. c

Solution: 9

$\omega = 2\pi f$

$\omega_0 = 2\pi \times 100$

$\omega_0 = 200\pi$ rad/sec.

$\omega^2 - \omega_0^2 = 2\alpha\theta$

$\omega = \omega_0 + \alpha t$

$0 = 200\pi + \alpha(5\times 60)$

$\omega = 0$ (∵ finally stops)

$\alpha = -\frac{200\pi}{300} = -\frac{2\pi}{3}$ rad/s^2

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\theta = (200\pi)(5\times 60) - \frac{1}{2}\left(\frac{2\pi}{3}\right)(5\times 60)^2$

$\theta = \pi 6\times 10^4 - \frac{\pi}{3}\times 25\times 3600$

$\theta = 60,000\pi - 39000\pi$

$\theta = 30000\pi$

(m) no. of rev. $= \frac{\theta}{2\pi} = \frac{30,000\pi}{2\pi}$

$n = 15000$ rev.

OR

$\theta = \frac{\omega+\omega_0}{2}\times t$

$= \frac{100+0}{2}\times 5\times 60$

$= 15000\pi$ rev

Ans. c

Solution: 10

$\alpha = -\frac{3}{2}t^2 \quad \omega_0 = 10 \text{ rad/s}$

$\frac{d\omega}{dt} = -\frac{3}{2}t^2 \Rightarrow \int_{10}^{\omega} d\omega = \int_0^t -\frac{3}{2}t^2 dt$

$\omega - 10 = \left(-\frac{3}{2}\frac{t^3}{3}\right)_0^t$

$$\boxed{\omega = \left(10 - \frac{t^3}{2}\right) \text{ rad/sec}}$$

$\frac{d\theta}{dt} = \left(10 - \frac{t^3}{2}\right)dt$

$\int_1^{\theta} d\theta = \left[10t - \frac{t^4}{8}\right]_0^t \Rightarrow \boxed{\theta = 1 + 10t - \frac{t^4}{8} \text{ rad}}$

at; $t = 1$ sec; $\omega = \frac{19}{2} = 9.5$ rad/s.

$\theta = 1 + 10 - \frac{1}{8} = \frac{87}{8}$ rad

at; $t = 2$ sec; $\omega = 10 - 4 = 6$ rad/s

$\theta = 1 + 20 - 2 = 19$ rad

Ans. b

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