\[
\sin 30^\circ = \cos 60^\circ = \frac{1}{2} \quad \sin 60^\circ = \cos 30^\circ = \frac{\sqrt{3}}{2} \approx 0.87 \quad \sin 45^\circ = \cos 45^\circ = \frac{\sqrt{2}}{2}
\]

1. An angle \(\beta=200^\circ\) expressed in radians is:
   
   (a) \(\frac{9\pi}{10}\) rad  
   (b) \(\frac{3}{4\pi}\) rad  
   (c) \(\frac{10\pi}{9}\) rad  
   (d) \(\frac{9}{10\pi}\) rad

2. The instantaneous angular acceleration is defined as:
   
   (a)  
   (b)  
   (c) 

   \[
   \omega = \frac{\Delta \theta}{\Delta t} \quad \alpha = \frac{d\omega}{dt} = \lim_{\Delta t \to 0} \frac{\Delta \omega}{\Delta t} \quad \omega = \frac{d\theta}{dt} = \lim_{\Delta t \to 0} \frac{\Delta \theta}{\Delta t}
   \]

3. A hard drive rotates with 600 rpm (revolutions per minute). What is its angular velocity \(\omega\)?
   
   (a) 20 rad/s  
   (b) \(20\pi\) rad/s  
   (c) 60 rad/s  
   (d) \(60\pi\) rad/s

**Questions 4-5.** An object, initially at rest, starts to rotate with constant angular acceleration \(\alpha=10\ \text{rad/s}^2\).

4. What is its angular velocity after 10 s?
   
   (a) 50 rad/s  
   (b) 100 rad/s  
   (c) \(50\pi\) rad/s  
   (d) \(100\pi\) rad/s

5. How many revolutions does the object make in 10 s?
   
   (a) 250  
   (b) 500  
   (c) \(250/\pi\)  
   (d) \(500/\pi\)

**Questions 6-7.** An object rotates with constant angular velocity \(10\ \text{rad/s}\).

6. What is the linear velocity of a point located 10 cm from the axis or rotation?
   
   (a) 0  
   (b) 1 m/s  
   (c) 10 m/s  
   (d) \(2\pi\) m/s

7. What is radial acceleration of a point located 10 cm from the axis of rotation?
   
   (a) 0  
   (b) 10 m/s\(^2\)  
   (c) 20 m/s\(^2\)  
   (d) \(10\pi\) m/s\(^2\)
Questions 8-9. Thin cylinder wheel of radius R=10 cm can rotate about an axis that passes through its center, as in the picture. The magnitudes of the two forces are $F_1=10$ N and $F_2=20$ N.

8. The magnitude of the net torque on the wheel due to these two forces is:

(a) 1 Nm  (b) 1.13 Nm  (c) 1.92 Nm  (d) 2.05 Nm

9. Due to this net torque the wheel rotates:

(a) clockwise  (b) counterclockwise  (c) does not rotate

10. Angular momentum of a particle is defined as:

(a) $\vec{\ell} = \vec{p} \times \vec{\omega}$  (b) $\vec{\tau} = \vec{L} \cdot \vec{p}$  (c) $\vec{\ell} = \vec{r} \times \vec{p}$  (d) $I = mr^2$

11. Newton’s second law for rotations can be expressed as?

(a) $\sum \vec{L} = m\vec{\omega}$  (b) $\sum \vec{F} = \frac{d\vec{p}}{dt}$  (c) $\sum \vec{\tau} = \frac{d\vec{L}}{dt}$  (d) $\sum \vec{F} = \frac{d\vec{L}}{dx}$

12. The law of conservation of angular momentum states that the total angular momentum of a system remains constant if the net external torque acting on the system is zero.

(a) True  (b) False  (c) cannot be answered
Questions 13-14. Three particles, each of mass $m$, are located at the corners of an equilateral triangle whose sides have length $a$, as shown in the picture below.

13. The moment of inertia about $x$-axis is:
   (a) $ma^2$  (b) $\frac{3}{4}ma^2$  (c) $\frac{5}{4}ma^2$  (d) $3ma^2$

14. The moment of inertia about $y$-axis is:
   (a) $ma^2$  (b) $\frac{3}{4}ma^2$  (c) $\frac{5}{4}ma^2$  (d) $3ma^2$

15. Vectors $A$ and $B$ are given as $A=3i-4j-k$ and $B=-2i+j+2k$. Vector product $A \times B$ is:
   (a) $2i - 3j+7k$  (b) $3i+7j-4k$  (c) $-7i-4j-5k$  (d) none of these

16. A force $F=10N \, i$ acts at $r=1m \, i + 1m \, j$. What is the torque vector $\mathbf{\tau}$ due to this force?
   (a) $10i \, Nm$  (b) $-10k \, Nm$  (c) $5j \, Nm$  (d) $20k \, Nm$

Questions 17-18. A sphere of mass $M=1$ kg and radius $R=1$ m rotates with constant angular velocity $\omega=1$ rad/s about an axis through its center. The moment of inertia of the sphere is $I=\frac{2}{5}MR^2$.

17. The rotational kinetic energy of the sphere is:
   (a) 0.1 J  (b) 0.2 J  (c) 0.5 J  (d) 1 J

18. The radius of the sphere suddenly doubles, but its mass stays the same. What is the new angular velocity of rotation?
   (a) 0.25 rad/s  (b) 0.5 rad/s  (c) 1 rad/s  (d) 1.25 rad/s
**Questions 19-20.** A solid cylinder of mass $M$ and radius $R_0$ rolls down an incline as shown in the picture. The moment of inertia of the cylinder is $I = \frac{1}{2}MR_0^2$.

19. What will be the speed of the cylinder at the bottom of the incline if it starts from rest at a vertical height $H$?

(a) $\sqrt{2gH}$  (b) $\frac{4}{\sqrt{3}}gH$  (c) $\frac{10}{\sqrt{7}}gH$  (d) $\sqrt{gH}$

20. How many times is the translational kinetic energy of the cylinder at the bottom of the incline greater than its rotational kinetic energy?

(a) 1.5  (b) 2  (c) 2.5  (d) 3