

QUIZ CUBES

Class 11/12 | AP Physics | IIT JEE | NEET



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Kinetic Energy and Forces in Rolling

The following questions are concept based and a recap of the lesson. For questions with higher level difficulty, watch videos in the course.

1. A solid sphere of mass M and radius R rolls smoothly down an incline of angle θ . Which of the following is the correct expression for its acceleration along the ramp?

- A. $a = g \sin \theta$
- B. $a = g \sin \theta / 2$
- C. $a = g \sin \theta / (1 + I/MR^2)$
- D. $a = g \cos \theta$

Correct Answer: C

Explanation:

For rolling without slipping, the linear acceleration $a = g \sin \theta / (1 + I/MR^2)$. This arises from combining Newton's laws for translation and rotation with the constraint $a = R\alpha$.

2. The total mechanical energy of a rolling object is conserved only if:

- A. The object is sliding without friction
- B. Air resistance is balanced by static friction
- C. There is no energy loss due to friction or air resistance
- D. The object rolls at constant speed

Correct Answer: C

Explanation:

Conservation of mechanical energy requires no non-conservative forces (like kinetic friction or air resistance) to be doing work. Static friction does not dissipate energy.



3. A rolling cylinder starts from rest at a height h . What is its total kinetic energy at the bottom (neglecting friction losses)?

- A. $\frac{1}{2} Mv^2$
- B. $\frac{1}{2} I\omega^2$
- C. Mgh
- D. $\frac{1}{2} Mv^2 + \frac{1}{2} I\omega^2$

Correct Answer: D

Explanation:

The total mechanical energy is conserved: $Mgh = \text{translational KE} + \text{rotational KE} = \frac{1}{2} Mv^2 + \frac{1}{2} I\omega^2$.

4. A disk of mass 2 kg and radius 0.5 m rolls without slipping at $v_{\text{com}} = 4 \text{ m/s}$. Find the total kinetic energy of the disk. ($I = \frac{1}{2}MR^2$)

- A. 16 J
- B. 32 J
- C. 24 J
- D. 64 J

Correct Answer: C

Explanation:

$$\text{Translational KE} = \frac{1}{2} \times 2 \times 4^2 = 16 \text{ J}$$

$$\text{Rotational KE} = \frac{1}{2} \times I \times \omega^2$$

$$I = \frac{1}{2}MR^2 = 0.25 \text{ kg}\cdot\text{m}^2$$

$$\omega = v/R = 4/0.5 = 8 \text{ rad/s}$$

$$\text{Rotational KE} = \frac{1}{2} \times 0.25 \times 64 = 8 \text{ J}$$

$$\text{Total KE} = 16 + 8 = 24 \text{ J}$$

5. A wheel is rolling smoothly on a flat surface. Suddenly, a horizontal force is applied to its axle, increasing its forward speed. Which of the following happens?

- A. The point of contact begins to skid forward
- B. Static friction opposes the wheel's rotation
- C. ωR becomes greater than v_{com}
- D. No friction is involved since there's no slipping

Correct Answer: A

Explanation:

When you push the axle forward, the center-of-mass speeds up before ω can catch up, so $v_{\text{com}} > \omega R$ and the contact point actually skids **forward** relative to the ground. Static friction then acts **backward** to oppose that forward slip and accelerate the wheel's rotation.



6. In which case would the rolling object lose mechanical energy?

- A. When $v_{\text{com}} = \omega R$
- B. When friction is static
- C. When kinetic friction is acting
- D. When object is at rest

Correct Answer: C

Explanation:

Kinetic friction converts mechanical energy to heat. Static friction does not result in energy loss.

7. A solid cylinder of mass M and radius R rolls without slipping on a horizontal surface when a constant horizontal force F is applied at its center. What is the acceleration a of its center of mass?

- A. F / M
- B. $(1/2)(F / M)$
- C. $(2/3)(F / M)$
- D. $(3/4)(F / M)$

Correct Answer: C

Explanation:

1. **Translation:** The net force is F minus static friction f_s , so

$$F - f_s = M a.$$
2. **Rotation:** Static friction provides the only torque:

$$f_s R = I \alpha = \left(\frac{1}{2} M R^2\right) (\alpha)$$
 and rolling without slipping $\Rightarrow a = \alpha R$

$$\Rightarrow f_s R = \frac{1}{2} M R^2 (a / R) = \frac{1}{2} M a R$$

$$\Rightarrow f_s = \frac{1}{2} M a.$$
3. **Combine:**

$$F - \left(\frac{1}{2} M a\right) = M a$$

$$\Rightarrow F = \left(\frac{3}{2}\right) M a$$

$$\Rightarrow a = \left(\frac{2}{3}\right) (F / M).$$

8. Why does static friction act up the ramp for a rolling object coming down?

- A. To stop the object from accelerating
- B. To oppose the component of gravity
- C. To oppose the slipping of the contact point
- D. Because normal force is not vertical



Correct Answer: C

Explanation:

If the rolling body were to slip, it would do so down the ramp. Static friction acts up the ramp to oppose this tendency and enable rotation.

9. Which of the following is true if an object is rolling but starts slipping at point P?

- A. The frictional force becomes zero
- B. Friction transitions from static to kinetic
- C. The object continues pure rolling
- D. ωR still equals v_{com}

Correct Answer: B

Explanation:

Once slipping begins, the friction force changes from static to kinetic, and rolling without slipping no longer holds.

10. A hollow cylinder and a solid cylinder of the same mass and radius roll down the same incline. Which reaches the bottom first?

- A. Both reach at the same time
- B. Hollow cylinder
- C. Solid cylinder
- D. Depends on the incline angle

Correct Answer: C

Explanation:

Solid cylinder has a lower moment of inertia relative to MR^2 , so it accelerates faster and reaches the bottom first, assuming rolling without slipping.

