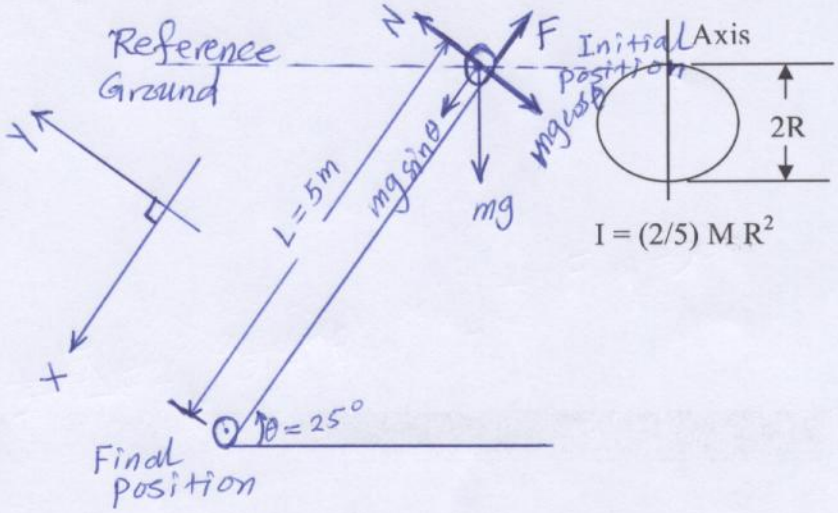
Physics 101- Chapter 12
Quiz No. 6

Name: Key	ID:	Sec: 28

A solid ball, whose radius R is 10 cm and whose mass M is 8.5 kg, rolls smoothly from rest down a 25 deg inclined plane whose length L is 5.0 m. What is the speed of the center of mass of the ball when it reaches the bottom of the inclined plane?



Newton's translation law:

$$\vec{F}_{net} = m\vec{a}$$

$$\sum F_x = ma_x$$

$$mg\sin\theta - F = ma_x \quad \text{— (1)}$$

$$\sum F_y = ma_y$$

$$N - mg\cos\theta = 0$$

$$N = mg\cos\theta \quad \text{— (2)}$$

Newton's rotational law:

$$\vec{\tau}_{net} = I\vec{\alpha}$$

$$Fr = I\alpha \quad \text{— (3)}$$

The relationship between the linear and rotational motion:-

$$v = \omega r, \quad a = \alpha r \quad \text{— (4)}$$

Formula (3) will become: $Fr = I\frac{a_x}{r}$

$$F = \frac{Ia_x}{r^2} \quad \text{— (5)}$$

Subistitute F from (5) into (1):-

$$mg\sin\theta - \frac{Ia_x}{r^2} = ma_x$$

$$a_x = \frac{mg\sin\theta}{m + \frac{I}{r^2}} = \frac{mgr^2\sin\theta}{mr^2 + I}$$

The linear acceleration of the center of mass:-

$$a_x = \left[\frac{8.5 \times 9.8 \times (0.1)^2 \sin 25}{8.5 + \frac{2}{5} \times 8.5 \times (0.1)^2}\right] = 2.94 \text{ m/s}^2$$

Motion with constant acceleration:-

$$v^2 = v_0^2 + 2a_x x$$

$$v^2 = 0 + (2 \times 2.94 \times 5) = 29.4$$

$$v = 5.4 \text{ m/s}$$