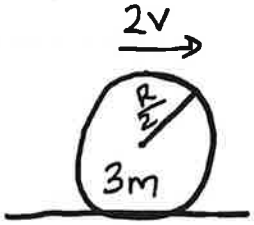
Who's doing this madness??? Key

AP Physics C: 7.6 Rotational Energy Practice

1. If you roll 3 sphere's down a slope and the spheres all have different radii and masses, which one would win the race?

_____Sphere 1 with a large radius and large mass
_____Sphere 2 with a small radius and large mass
_____Sphere 3 with large radius and small mass
_____They'd all reach at the same time

2. Calculate the total kinetic energy of the figure shown to the right, if the object is a sphere and the moment of inertia for a sphere is $I = \frac{2}{5}mr^2$. *(ans:* $8.4mv^2$*)*



$K_{total} = \frac{mv^2}{2} + \frac{I\omega^2}{2}$

$= \frac{3m(2v)^2}{2} + \frac{(\frac{2}{5}(3m)(\frac{R}{2})^2)(\frac{2v}{R/2})^2}{2}$

$= \frac{42mv^2}{5}$ or $8.4mv^2$

3. Four different objects: solid sphere, hollow sphere, solid cylinder and a hollow cylinder of the same mass and radius are used in an experiment.

a. If the objects are allowed to roll down a ramp, which would reach the bottom first? Justify. Solid sphere would have the smallest moment of inertia meaning you could gain spin faster to reach the bottom.

b. If they were rolled linearly towards the ramp all at the same linear velocity, which would roll the highest? Justify. Solid sphere. because it has the lowest moment of interia so it would lose spin the fastest coming to a stop.

4. A graph of angular velocity and time is given. What does the derivative and integral calculate?

Derivative: angular acceleration

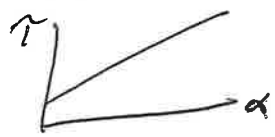
Integral: angular displacement

5. A graph is given with the y-axis being torque and the x-axis being angular displacement. What would the integral of this calculate?

$area = \tau \cdot \theta$ ← same as F·d linearly so this must be work

angular work = angular KE

6. A graph of torque on the y-axis and angular acceleration on the x-axis is given, what does the derivative calculate?

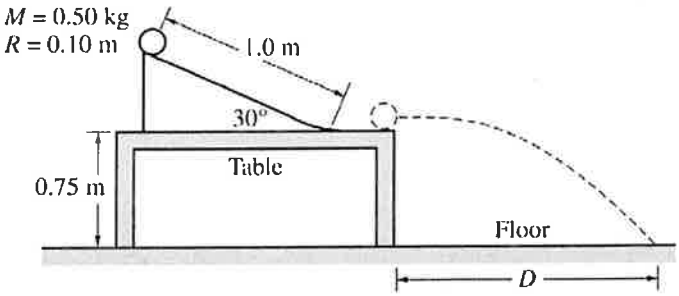


derivative = slope = τ/α ← linearly is $F/a = m$

moment of inertia

Who's doing this madness???_____

2017 AP® PHYSICS C: MECHANICS FREE-RESPONSE QUESTIONS



3. A uniform solid cylinder of mass $M = 0.50$ kg and radius $R = 0.10$ m is released from rest, rolls without slipping down a 1.0 m long inclined plane, and is launched horizontally from a horizontal table of height 0.75 m. The inclined plane makes an angle of 30° with the horizontal. The cylinder lands on the floor a distance D away from the edge of the table, as shown in the figure above. There is a smooth transition from the inclined plane to the horizontal table, and the motion occurs with no frictional energy losses. The rotational inertia of a cylinder around its center is $MR^2/2$.

(a) Calculate the total kinetic energy of the cylinder as it reaches the horizontal table.

(b) Calculate the angular velocity of the cylinder around its axis at the moment it reaches the floor.

(c) Calculate the ratio of the rotational kinetic energy to the total kinetic energy for the cylinder at the moment it reaches the floor.

(d) Calculate the horizontal distance D.

A sphere of the same mass and radius is now rolled down the same inclined plane. The rotational inertia of a sphere around its center is $\frac{2}{5}MR^2$.

(e)

i. Is the total kinetic energy of the sphere at the moment it reaches the floor greater than, less than, or equal to the total kinetic energy of the cylinder at the moment it reaches the floor?

____ Greater than ____ Less than ____ Equal to

Justify your answer.

ii. Is the rotational kinetic energy of the sphere at the moment it reaches the floor greater than, less than, or equal to the rotational kinetic energy of the cylinder at the moment it reaches the floor?

$K = \frac{Iw^2}{2}$

____ Greater than ____ Less than ____ Equal to

Justify your answer.

iii. Is the horizontal distance the sphere travels from the table to where it hits the floor greater than, less than, or equal to the horizontal distance the cylinder travels from the table to where it hits the floor?

____ Greater than ____ Less than ____ Equal to

Justify your answer.

a) Total energy is conserved due to rolling object. So the total KE at table is same as potential energy at top of incline.

$U = mgh = .5(9.8)(1\sin(30)) = \boxed{2.45\text{ J}}$

b) the angular velocity it has as it leaves the table is the same as it reaches the floor because nothing makes it spin faster through the fall.

$2.45 = \frac{(.5)v^2}{2} + \frac{\frac{.5(.1)^2}{2}\left(\frac{v}{.1}\right)^2}{2}$

$v = 2.56\text{ m/s}$

$\omega = \frac{v}{r} = \frac{2.56}{.1} = \boxed{25.6\ \frac{\text{rad}}{\text{sec}}}$

c) $$\frac{KE_{rot}}{KE_{tot}} = \frac{\frac{Iw^2}{2}}{mgh} = \frac{\frac{\left(\frac{.5(.1)^2}{2}\right)\left(\frac{2.56}{.1}\right)^2}{2}}{(.5(7.8)(.75+1\sin(30))}$$

$$= .\frac{8192}{6.125} = \boxed{.133}$$

d) $$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2(.75)}{9.8}} = .39 \text{ sec}$$

$$v = \frac{d}{t}$$

$$d = v \cdot t = (2.56)(.39) = \underline{1 \text{ m}}$$

e) i. Equal. The total energy is the same as the total potential energy at the top and the height and mass of the object is the same.

ii. less than because the rotational moment of inertia would be smaller for the sphere making it rotate faster so you'd assume from the formula $K = \frac{Iw^2}{2}$ the sphere would be greater but the sphere would win in a race so it's linear speed is greater than the cylinder. Since the total energy is the same for both then the sphere must have a smaller $KE_{rotational}$ since it has a larger linear KE.

iii. Greater than because the sphere has a larger linear speed than the cylinder.