Phys 131 2023

Final Review

Final

When your class meets regularly	When the final happens
Section 001 10am	Mon, May 15, 10 - 11:50am
Section 002 11am	Weds, May 17, 10 - 11:50am

Covers: Entire Semester

Bring: * Calculator - note about using mine

* Total four 3" x 5" single-sided cards (or equiv surface area)

Review: Previous finals 2018, 2022] all questions.

Note: version 2 only has solutions for questions different to version 1

This review: Only covers Ch 10, 11, 12, 13

Chapters 10 - 12

Equations

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$v_t = \omega r$

$a_t = \alpha r$

$I = \sum m_i r_i^2$

others given

$\tau = \vec{r} \times \vec{F}$

$= rF\sin\phi$

$\tau = I\alpha$

vector cross product rules

$K_{rot} = \frac{1}{2}I\omega^2$

$\vec{L} = I\vec{\omega}$

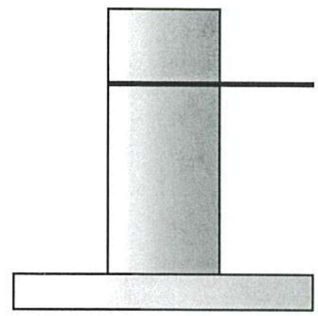
Quiz 1 typo

~ 40% ~ better,

~ 40% ~ 60%

311 Flywheel and axle

A particular flywheel is a solid disk with mass 0.150 kg and radius 0.075 m. This is mounted to an 0.400 kg axle which is a hollow cylinder with radius 0.020 m. The entire arrangement is initially at rest and is subsequently pulled with constant tension by a string that is wound around the axle. It reaches an angular velocity of 40 rad/s in 5.0 s. A side view is illustrated. Determine the tension in the string. *(131Sp2023)*



Answer: Rotational kinematics → angular acceleration

Rotational dynamics → torque → tension in string.

$\omega_0 = 0\,\text{rad/s}$

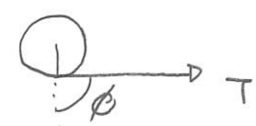
$\omega = 40\,\text{rad/s} \quad t = 5.0\,\text{s}$

Angular acceleration: $\omega = \omega_0 + \alpha t$

$$40\,\text{rad/s} = 0\,\text{rad/s} + \alpha\, 5.0\,\text{s}$$

$$\Rightarrow \alpha = 8.0\,\text{rad/s}^2$$

Rotational dynamics $\tau_{net} = I\alpha$



$$\tau_{net} = \tau_{string} + \underbrace{\tau_{grav} + \tau_{axle}}_{=0 \text{ since } r=0}$$

$$\tau_{string} = rT\sin\phi = r_{cyl} T \sin 90^\circ = rT$$

$$\Rightarrow r_{cyl} T = I\alpha \Rightarrow T = \frac{I\alpha}{r_{cyl}}$$

But $I = I_{cylinder} + I_{disk} = M_{cyl} r_{cyl}^2 + \frac{1}{2} M_{disk} r_{disk}^2$

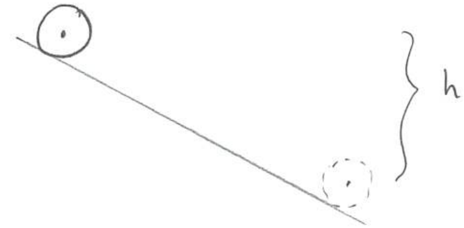
$$= 0.400\,\text{kg} \times (0.020\,\text{m})^2 + \frac{1}{2}\, 0.150\,\text{kg} \times (0.075\,\text{m})^2$$

$$= 1.6\times10^{-4}\,\text{kg m}^2 + 4.2\times10^{-4}\,\text{kg m}^2 = 5.8\times10^{-4}\,\text{kg m}^2$$

$$T = \frac{5.8\times10^{-4}\,\text{kg m}^2 \times 8.0\,\text{rad/s}^2}{0.020\,\text{m}} = 0.23\,\text{N}$$

Quiz2 80% – 90% $\}$ 90%

To analyze this note that energy is conserved.



$$E_f = E_i$$

$$K_{rot f} + K_{trans f} + U_{gf} = \cancel{K_{rot i}} + \cancel{K_{trans i}} + U_{gi}$$

$$\frac{1}{2} M v_f^2 + \frac{1}{2} I \omega_f^2 = U_{gi} - U_{gh} = mgh$$

$$\frac{1}{2} M v_f^2 + \frac{1}{2} I \omega_f^2 = mgh.$$

For the slipping ball $\omega_f = 0 \Rightarrow v_f^2 = 2gh \Rightarrow v_f = \sqrt{2gh}$ slipping

For the rotating ball $\omega_f = v_f/R \Rightarrow \frac{1}{2} M v_f^2 + \frac{1}{2}\frac{I}{R^2} v_f^2 = mgh$

$$\Rightarrow v_f^2 + \frac{I}{MR^2} v_f^2 = 2gh$$

$$\Rightarrow v_f^2 (1 + I/MR^2) = 2gh$$

$$\Rightarrow v_f = \sqrt{2gh/(1 + I/MR^2)} \quad \text{rolling}$$

$1 + I/mR^2$ is larger than 1 $\Rightarrow v_f$ rolling < v_f slipping

need

Quiz3 30% – 90% $\}$ 60% → 80%

B = C < A

Chapter 13

$$F = G\frac{M_1 M_2}{r^2} \qquad U = -G\frac{M_1 M_2}{r}$$

How to: use Newton's Second Law + Univ law of gravity to derive results about

* gravitational acceleration
* orbital motion

346 Orbiting satellite

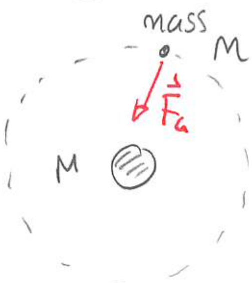
A satellite orbits a planet with mass M_p in a circular orbit with radius r. The satellite's speed is constant. *(131Sp2023)*

a) **Starting with and using** Newton's Second Law, derive an expression for the satellite's speed in terms of M_p and r.

b) Determine the speed of a satellite in a uniform circular orbit 60000 m above the surface of the dwarf planet Ceres (mass 9.4×10^{20} kg and radius 4.7×10^5 m).

essential

Answer: a) $F = ma$ and $a = v^2/r$



$$F_G = G\frac{\cancel{m} M_p}{r^2} = \cancel{m} a$$

$$G\frac{M_p}{r^2} = \frac{v^2}{r}$$

$$\Rightarrow v^2 = \frac{GM}{r} \Rightarrow v = \sqrt{\frac{GM}{r}}$$

b) $r = 4.7\times10^5\,\text{m} + 6.0\times10^4\,\text{m} = 5.3\times10^5\,\text{m}$

$$v = \sqrt{\frac{6.67\times10^{-11}\,\text{Nm}^2/\text{kg}^2 \times 9.4\times10^{20}\,\text{kg}}{5.3\times10^5\,\text{m}}}$$

$= 344\,\text{m/s}$ $\boxed{5}$

Course Evals: