PHYS-1050-01,02 Final exam review guide

The final exam will be about 50% on chapter 8 and 50% on prior material. This review guide covers only chapter 8; see other review guides for the other material.

Chapter 8 - Rotational Motion

Angular position is measured with angle θ. The equations in this chapter assume θ is in radians. 1 rotation = 2π radians = 360°.

Arc length, l, is $l = r\theta$. This is also a good approximation for straight line length at distance r if θ is small.

Angular velocity is $\omega = \Delta\theta/\Delta t$, measured in either rad/s or s^{-1}.

Period, T is time for 1 period. Frequency, f, is rotations per time, $f = 1/T = \omega/2\pi$. 1 rpm is 1 rotation per minute and 1 Hz is 1 rotation per second.

Angular acceleration is $\alpha = \Delta\omega/\Delta t$, measured in either rad/s^2 or s^{-2}.

From arc length, velocity at r is $v = r\omega$ and tangential acceleration at r is $a_{tan} = r\alpha$.

Don't forget that centripetal acceleration is still $a_{cent} = v^2/r$.

Total acceleration is vector sum: $\mathbf{a}_{total} = \mathbf{a}_{tan} + \mathbf{a}_{cent}$.

Rotational kinematics equations are essentially the same as those for linear kinematics.

Torque is the rotational force. It is $\tau = F_\perp r = Fr_\perp = Fr \sin\theta$. Measured in N·m with the interpretation of being F newtons at a radius of r meters (in foot-pounds in English system).

From Newton's second law, $\tau = I\alpha$. More precisely, $\sum \tau = I\alpha$, because it is net torque that matters.

Moment of inertia, I, depends on mass and mass distribution. For an object of mass M at radius R, $I = MR^2$. Units are kg·m^2.

Objects with mass closer to the center have lower moments of inertia. Examples: a disk has $I = 1/2\ MR^2$, a rod has $I = 1/12\ ML^2$, a sphere has $I = 2/5\ MR^2$, etc.

Moment of inertia depends on the rotational axis.

For objects with multiple components, $I_{total} = I_1 + I_2 + \ldots$ (assuming same rotational axis).

Rotational kinetic energy is $KE_{rot.} = I\omega^2/2$, much like $KE_{trans.} = mv^2/2$ for translational case. Energy is in J, as always.

Total kinetic energy is $KE_{total} = KE_{trans.} + KE_{rot.}$.

Rotational work is $W = \tau\Delta\theta$, much like $W = F\Delta x$ for translational case.

Angular momentum is $L = I\omega$, much like $p = mv$ for translational case. Units are kg·m/s.

In the absence of external forces, angular momentum is conserved.

The following quantities are scalars: T, f, I, KE, W.

The following quantities can be vectors: $\boldsymbol{\theta}, \boldsymbol{\omega}, \boldsymbol{\alpha}, \boldsymbol{\tau}, \mathbf{L}$. The vector direction is parallel to the rotational axis, found using the right-hand rule.