The final will cover rotational motion and all other topics that we covered after that. Necessarily, though, understanding of main concepts of previous chapters will be necessary (e.g. Newton's law, friction, tension, Hooke's law, etc.) as the later subjects are built on those concepts.

Work-Energy Theorem

- Net work done on an object A = Kinetic energy change of object A
- is always applicable, including cases in which non-conservative forces are involved

Kinetic Energy (K)

- $K = m v^2 / 2$
- $K = I \omega^2 / 2$ for a pure rotation
- $K = M V^2 / 2 + K_{rot}$, where $K_{rot} = I \omega^2 / 2$ and V is the speed of the center of mass
  if a non-point object is moving as a whole (V) as well as rotating w.r.t. the center of mass
  (thus, in this case, I and ω should be defined w.r.t. the axis going through the center of mass)

Potential Energy (U)

- gives force $F(x) = -dU/dx$ (when U is dependent only on one coordinate x)

Mechanical Energy Conservation

- means that $K + U$ is a constant of time.
- is most useful in problems where time is not asked, or asked only qualitatively.
- is not applicable, if non-conservative forces are involved (like friction, drag).
- is applicable for rolling if rolling friction is zero (negligible wheel deformation).
- is applicable for a static friction of a non-deformed wheel, since that friction does not do any work!

Rotational Motion

- is analogous to the one-dimensional linear motion with the following simple substitution table
  $$m \to I, x \to \theta, v \to \omega, a \to \alpha, F \to \tau$$
- The rotational inertia: $I = \sum m_i D_i^2$
- The torque, $\vec{\tau} = \vec{r} \times \vec{F}$, (magnitude is $rF \sin\theta$)
- The angular momentum, $\vec{L} = \vec{r} \times \vec{p}$
- The fundamental equation (Newton's law), $d\vec{L}/dt = \vec{\tau}$, where $\vec{\tau}$ is the net torque, applicable in an inertial reference frame *or* in the center of mass frame.
- The angular momentum is conserved for a spinning ice skater, or a diver, or for any isolated system.
- $\tau = I \alpha$ is also a useful, but less general equation (OK for this course).
- $\vec{L} = I \vec{\omega}$ is another such equation.
- When L is already very large (like for a gyroscope),
  a small τ causes $\vec{L}$ to simply change its direction slightly according to $d\vec{L}/dt = \vec{\tau}$. The result may seem non-intuitive!

Oscillation and Simple Harmonic Oscillation

- frequency, period, angular frequency – their relations?
- (angular) frequency for mass on spring, simple pendulum, physical pendulum, etc.
- Expression of total energy in terms of k and A (amplitude)?
- Expression of total energy in terms of m and maximum speed?
- Can you explicitly prove the energy conservation for a SHM?

Many Particles, Collision, Gravity, and Statics

- **See the concluding slides** for Lec_12-01.pdf, Lec_12-03.pdf, and Lec_12-05.pdf.
- Can you explain the "bear on high wire" problem using the following concepts: the equilibrium, the stability, the potential energy, and the SHM? (This problem WILL be on the final exam!)