Review for Final Exam

- Exam format:

- 9 problems, 10 pts
- Set of short-answer conceptual questions, 10 pts
- One bonus problem, 5 pts

- Time: Tues. May. 9, 8:00-11:00am

- Place: Physics, Room 303

- Test materials:

- Pencil, eraser, calculator, and student ID
- formula sheet provided

- Responsible for:

- Chapters 1-11
- All homework assignments, previous tests
- Example problems done in class, notes

Material Covered

Chapter 1: 1.1-1.12	Test 1
Chapter 2: 2.1-2.9	
Chapter 3: 3.1-3.16	Test 2
Chapter 4: 4.1-4.5, 4.8-4.12, 4.17	
Chapter 5: 5.1-5.10	Test 3
Chapter 6: 6.1-6.13	
Chapter 7: 7.1-7.5	
Chapter 8: 8.1-8.4	
Chapter 9: 9.1-9.2	
Chapter 10: 10.1-10.4, 10.6	
Chapter 11: 11.1-11.7, 11.11	

Material Covered After Test 3

- Chapter 7: **Internal Energy (7.3-7.4)**
  - spring potential energy
  - nuclear potential energy

- Chapter 8: **Quantized Energy**
  - electronic energy levels of the hydrogen atom
  - energy level diagrams
  - quantized harmonic oscillator energies
  - molecular vibrational energies
  - infinite square well energies
  - transitions between energy levels via photons and collisions

- Chapter 9: **Rotational Dynamics**
  - Torque, Newton's 2^{nd} Law $\Sigma\tau = I\alpha$
  - Moment of inertia
  - Rotational work and kinetic energy

- Chapter 9 (Cont'd)

- Energy principle with rotation
- integral relations for moment of inertia, mass, and center of mass (cartesian, 1D)
- linear, areal, and volume mass densities

- Chapter 11: **Angular Momentum**

- static equilibrium with torque
- angular momentum
- conservation of angular momentum
- cross product of vectors
- vector nature of angular properties
- quantized angular momentum/Bohr model

- Chapter 10: **Collisions**

-1D/2D collisions with energy conservation

Example Problem

A 0.200-m bar with a mass of 0.750 kg is released from rest in the vertical position. A spring is attached, initially unstrained, and has a spring constant of 25.0 N/m. Find the tangential speed with which the free end strikes the horizontal surface. (drawing to be provided)

<u>Solution:</u>

Bar rotating with axis at one end → rotational KE, no translational KE

Bar falls from some height → gravitional PE (U_g)

A spring is attached to bar → spring PE (U_s)

Bar → rigid body → need moment of inertia

→ Use Energy Principle

$$E = K_R + U_g + U_s$$

$$\omega_i = 0, x_i = 0$$

$$E_i = mg\frac{h}{2}, \qquad E_i \neq mgh$$

$y_i \neq h$ since this would mean all mass of rod is at $y_i = h$, but mass is distributed. So, take mass to be located at center of gravity

$$y_f = 0, U_{g,f} = 0$$

$$E_f = \tfrac{1}{2} I\omega_f^2 + \tfrac{1}{2} kx_f^2$$

$$I_{rod} = \tfrac{1}{3} mL^2, \quad \mathbf{v}_f = \mathbf{v}_t = r\omega_f = L\omega_f$$

$$E_f = \tfrac{1}{2}\left(\tfrac{1}{3} mL^2\right)\left(\frac{\mathbf{v}_t}{L}\right)^2 + \tfrac{1}{2} kx_f^2$$

$$E_f = \tfrac{1}{6} m\mathbf{v}_t^2 + \tfrac{1}{2} kx_f^2$$

$$x_f = ?$$

From geometry of problem

$$x_f = \sqrt{0.2^2 + 0.1^2} - 0.1 = 0.1236\ \text{m}$$

Return to Conservation of Energy and solve for v_t

$$E_f = \tfrac{1}{6} m v_t^2 + \tfrac{1}{2} k x_f^2 = E_i = mg\frac{h}{2} = mg\frac{L}{2}$$

$$\tfrac{1}{6} m v_t^2 = mg\frac{L}{2} - \tfrac{1}{2} k x_f^2$$

$$\mathbf{v}_t = \sqrt{3gL - 3\frac{k}{m} x_f^2}$$

$$\mathbf{v}_t = \sqrt{3(9.80)(0.20) - 3\frac{25.0}{0.750}(0.1236)^2}$$

$$\mathbf{v}_t = \sqrt{5.88 - 1.528} = \boxed{2.09\ \mathbf{m/s}}$$

Example: Problem P31, Chapter 11

At t_i= 15.0 s, a particle has angular momentum <3,5,-2> kg m^2/s relative to location A. A constant torque <10,-12,20> Nm relative to location A acts on the particle. At t_f=15.1 s, what is the angular momentum of the particle?