1. (7 points)
   (a) One version of Newton’s Second Law says
   \[ \sum F = \frac{d \vec{p}}{dt} \]

   By analogy, write down the equivalent rotational version of Newton’s Second Law in the box.

   (b) Under what general circumstances is angular momentum conserved?

2. (8 points) Imagine that you stand on a stationary platform (which can rotate about a vertical axis with frictionless bearings) holding a rotating bicycle wheel whose axis of rotation is vertical and which is rotating CW. You twist the wheel axis from vertical to horizontal. What happens to you? **Why?** Be specific.

3. [25 pts] The figure below shows a uniform rod of length \(d\) and mass \(M\) pivoted at the top. The rod, which is initially at rest, is struck by a blob of putty of mass \(m = M/2\) at a point \(x = 0.75d\) below the pivot. Assume that the putty sticks to the rod. \(I_{\text{rod,com}} = (1/12) M d^2\)

   (a) Explain why mechanical energy is **not** conserved **during** the collision.

   (b) Solve for the initial speed for the putty that will cause the rod-putty system to swing up until the rod is horizontal. Your answer should be in terms of \(M\), \(g\), and \(d\), and known constants.

   **Note – Not enough space here**
4. A uniform rod of weight 22.0 N and length 2.50 m is inclined at an angle 50.0° to the horizontal. Its upper end is supported by a horizontal rope tied to the rod at 1.75 m (from the end of the rod on the ground) and to the wall, and its lower end rests on a rough floor 0.50 m from the base of the wall. The coefficient of static friction between the rod and the floor is 0.500 and the coefficient of kinetic friction is 0.350. The weight suspended from the top of the rod is 40.0 N. Assume the rod does not slip on the floor.

(a) Draw a force diagram showing (and labeling) all of the forces acting on the rod.
(b) Find the contact force of the floor on the rod (both components and write it using \( \hat{i}, \hat{j} \) notation) and the tension in the horizontal rope.

(c) Does the force due to the floor act parallel to the rod? yes no (Circle one.)
Explain how you know.
5. (40 points) A mass \((m = 300.0 \text{ g})\) on a spring is oscillating with simple harmonic motion. The mass is moving in the direction indicated by the arrow but has no displacement at the moment the observer starts timing it (i.e. \(x = 0.0 \text{ cm}\) at \(t = 0.0 \text{ s}\)). Snapshots of the displacements of the mass at various times are shown in the diagram below. The arrows in the diagram show the direction of the velocity of the mass in snapshots #1, 3, and 5. Neglect the mass of the spring.

(a) Sketch a graph of the displacement of the spring from its equilibrium position in centimeters for times between 0.0 s and 4.0 s. (Always label graph axes!)

(b) Sketch a graph of the velocity of the mass:
(c) Determine the total mechanical energy of the mass/spring system in snapshot #1. Determine the total mechanical energy of the mass/spring system in snapshot #2. Clearly show your calculations or explain your reasoning.

(d) What are the velocities of the mass in snapshots #2 and #4?

(e) Suppose we use the same spring as shown above, but with half the mass on it. We pull the mass up to $y = +2.9$ cm and release it at $t = 0.0$s. Sketch a graph of the displacement:

![Graph of displacement vs time]

(f) Determine the values and units of the numbers you need to specify the for the oscillation, and fill in the blanks in the equation for the oscillation (for the new mass you used in part (e)):

$$y(t) = \cos \left[ \, \right]$$

6. (5 points) In simple harmonic motion: (circle all that apply)

A. the acceleration is constant.
B. the velocity is greatest at the maximum displacement.
C. the period depends on the amplitude.
D. the acceleration is greatest at zero displacement.
E. the acceleration is greatest when the velocity is zero.