Physics 21 Practice Final - 3 hours
2 Pages - turn over!!

Harry Nelson

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Write your answers in a blue book. Calculators and one page of notes (both sides) allowed. No textbooks or wireless communications allowed. *Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately.* Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**
For numerical work, you can always take the acceleration of gravity to be $g = 10\,\mathrm{m/s^2}$.

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1. Wayne pushes a hockey puck of mass $m = 0.3\,\mathrm{kg}$ that is in a frictionless ice rink with a constant force of $F = 3\,\mathrm{N}$. Find, symbolically and numerically, the instantaneous power Wayne applies to the puck as a function of time, and evaluate that power at time $t = 2\,\mathrm{s}$.

2. A uniform bar of length L and mass M rests horizontally on two narrow supports. The first support is a distance of $L/3$ from the left end of the bar, and the second support is a distance of $7L/8$ from the left end. Find the force exerted by each of the supports on the bar, in terms of M, L, and g.

3. A wheel with a rotational inertia of 4 $\mathrm{kg{\cdot}m^2}$ is rotating with an angular speed of 900 revolutions/minute on a shaft whose rotational inertia is negligible. A second wheel, initially at rest with a rotational inertia of 2 $\mathrm{kg{\cdot}m^2}$ is suddenly coupled to the same shaft. What is the final angular speed of the resultant combination of the shaft and the two wheels?

4. A thin ring of mass M and radius R is hung on a peg on a wall, so that the plane of the ring is parallel to the plane of the wall. The ring swings back and forth about the axis formed by the peg, which is parallel to the axis of the ring. Find the period of the ring's oscillations in terms of g, M, and R.

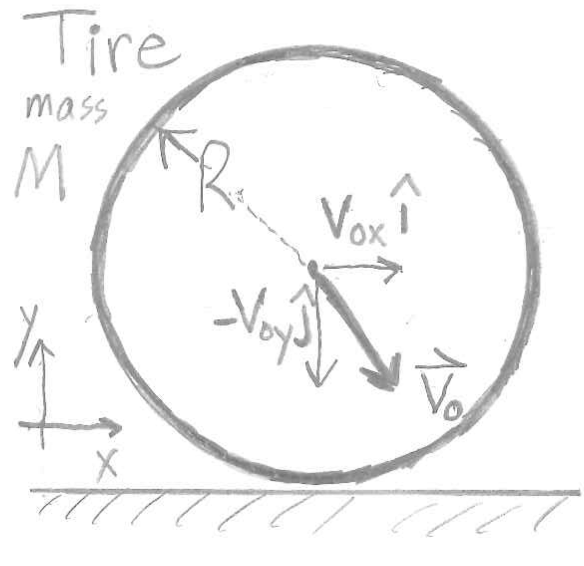

Figure 1: Problem 5.

5. A thin tire of mass M and radius R is just about to hit the ground, as shown in Figure 1, and it has a velocity with both x and y components, shown in the diagram as v_{0x}, $-v_{0y}$ (which is downward). The tire undergoes an elastic collision with the ground, and the friction beween the ground and the tire is sufficiently large to stop all slipping by the tire while it is in contact with the ground. When it bounces upward,

   (a) What angle does it make with the upward vertical?

   (b) What is its final angular velocity ω_f? Make a positive ω_f correspond to pointing *out* of the paper.

6. A family of bumblebee bats, each of which has a mass of $\mu = 1$ gram, lives in the demo area behind our lecture hall. They love it when a vertical spring with a mass $m = 1$ kg hanging from it is left out over night; they take turns trying to drive the spring into resonance. Because they can flap their wings and have slightly adhesive feet, they can drive the mass with a perfectly sinusoidal driving force, where the maximum force is their weight. When one bumblebee bat sits on the mass on the spring, the displacement from equilibrium is $h = 1/900$ of a meter. They have a contest where they each pick a different driving circular frequency ω, and the winner this year, named Puff, hit the theoretical maximum amplitude of $x_m = 1/3$ of a meter.

   (a) What driving circular frequency ω did Puff pick, symbolically and numerically?

   (b) The system's friction is characterized by a coefficient b; determine b symbolically and numerically.

   (c) Puff's friend Sniff picked a lower circular frequency that achieved a maximum of only $1/6$ of a meter. What circular frequency did Sniff pick, symbolically and numerically?