Midterm Exam 1

Print your full LAST name: ____________________________________________

Print your full first name: ______________________________________________

Print your full OSU student ID#: ________________________________________

Sign your name (full signature): _________________________________________

Print today’s date: ________________________________

#1 total: __________
#2 total: __________
#3 total: __________
#4 total: __________
Adjustment: __________
Appeal: __________
Exam total: __________ / 250
1. (60 points total) A playground carousel (a “merry-go-round”) is a horizontal platform that is free to rotate frictionlessly about a vertical axis (and you may assume that air drag is also negligible).

Without riders, the carousel has a moment of inertia (about its rotational axis) of $I_c$. In this situation, however, there is a single person, of mass $m_p$, riding. The person is initially standing at a distance $D_i$ from the axis of rotation, while the carousel turns at an initial angular speed $\omega_i$. Then the person moves to a different location on the platform and stands there instead—a distance $D_f$ from the axis. This relocation takes $1.67$ seconds, and during that time, the carousel’s angular velocity changes at a constant rate.

**Known values:** $I_c = 234 \text{ kg}\cdot\text{m}^2$, $m_p = 96.0 \text{ kg}$, $D_i = 0.578 \text{ m}$, $\omega_i = 4.38 \text{ rad/s}$, $D_f = 1.25 \text{ m}$

Through what angle magnitude does the carousel turn during the $1.67$ s when the person is changing position?
Use this page as additional space, if needed, for problem 1
2. (60 points total) Beginning from rest, a wheel of mass 21.5 kg and outer radius 0.754 m rolls, without slipping, down a slope, then onto level ground, losing 2.31 m in altitude. When it arrives on the level ground, its total kinetic energy is 66% $K_{T,cm}$ and 34% $K_{R,cm}$.

You may assume that the wheel’s center of mass is located at its geometric center, but you may not assume that the wheel has uniform mass density. Use local $g = 9.80 \text{ m/s}^2$, and ignore air drag and rolling friction.

What is the wheel’s moment of inertia, as measured around its center of mass?
Use this page as additional space, if needed, for problem 2
3. (60 points total) A stunt sled of mass \( m \) is in performing a vertical “loop-the-loop” maneuver along the inner surface of a frictionless circular track of (inner) radius \( R \). At the moment depicted here (this is a side view), the sled is located at the angular position \( \theta \), and it is sliding clockwise at speed \( v \).

Find an algebraic expression (using only known values) for the magnitude of the force being exerted by the track on the sled at this moment.

Model the sled as a point mass, and consider these values known: \( m, \theta, v, R, g \).
4. (70 points total) A certain baton consists of a thin, rigid, massless rod, which is 1.00 m long and has a different point mass attached to each end ($m_1 = 0.134 \text{ kg}$; $m_2 = 0.402 \text{ kg}$). You may assume $g = 9.80 \text{ m/s}^2$ and ignore air drag.

a. (_______ / 30 points) Initially, the baton rod is pinned at its center to a fulcrum supported by level ground. A force $F$ is applied as shown, at a point midway between $m_1$ and the fulcrum, so that the rod stays horizontal and in static mechanical equilibrium.

Find the magnitude of $F$. 

\[ \text{Diagram: } m_1, F, m_2 \]
b. (_______ / 40 points) Now $F$ is removed, and the baton is removed from the fulcrum by a student athlete. The athlete holds the baton at rest, then throws it vertically upward so that it rotates freely at 180 rpm. 2.40 seconds after its release, the baton’s center of mass returns to its original release height. How much work did the athlete need to do on the baton in order to throw it, from rest, as described?
GENERAL DIRECTIONS

Fill out the cover sheet completely, as indicated. Then follow the general guidelines below and the specific directions on each page for each item.

For ALL items (unless directed otherwise):
In all expressions and symbolic solutions, reduce them to simplest form.
In all final numerical answers, use standard SI units and three significant digits.
No item will be given full credit if it does not include valid reasoning/work to justify the solution/answer.
Correct answers alone are generally worth about 10% of the points.

For T/F/N items: Evaluate each statement as being either… demonstrably True (T), or
demonstrably False (F), or
with Not enough information (N) to declare it either True or False.
You must fully explain your reasoning, using any valid mix of words, diagrams and/or equations.
Little credit will be given for a correct T/F/N answer without a valid explanation to accompany it.

For items that give numeric values for the “knowns:”
Some credit (10%) will be offered for a numeric answer, with a little additional (about 15-20%) for showing the math to arrive at that answer. The rest of the credit (70-75%) is offered for your valid physics reasoning and work—the “setup” (equations and process) before the math starts.
Very little credit will be given for a correct answer without any work shown.

For items asking for symbolic solutions (algebraic expressions) and/or solution descriptions:
These items will state which symbols may be considered “known values” (and which may therefore appear in your final expression or be used in the first step of your solution description).
For an algebraic expression, again, about 75% of the credit is showing how the physics leads to the correct equations and use of the known values; the rest of the credit will be in solving/simplifying.
For a solution description problem, full credit (100%) is offered for a valid description. Remember that the test of a valid solution description is this: Could another person who knows math (but not physics) use your solution description—together with the known values given—to arrive at a correct answer?

Physical constants and other possibly useful information:

\[ g_{\text{earth.surface}} = 9.80 \text{ m/s}^2 \]