AP/Honors HW: Rotational Dynamics and Kinematics

Full Name, Period, AP/Honors: **due: 11/23**

0 Formulas (will be provided on the quiz as well)

- $\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$
- $L_{orbit} = mvr$ [1]
- $\vec{\tau}\Delta t = \Delta\vec{L}$
- $\vec{\theta} = \vec{\theta}_0 + \vec{\omega_0}t + \frac{1}{2}\vec{\alpha}t^2$
- $\vec{\omega} = \vec{\omega}_0 + \vec{\alpha}t$
- $KE = \frac{1}{2}mv^2 = \frac{1}{2}I\omega^2$
- $\vec{\alpha} = \vec{a} \times \vec{r}$

1 Multiple Choice

1. Which of these gives the analogue of $\frac{1}{2}mv_f^2 = FD$, (which is $W = \Delta E$ with a force that is nonconservative and no change in potential energy) for the rotational case?

   A. $\tau\theta = \frac{1}{2}I\omega_f^2$

   B. $\tau\theta R = \frac{1}{2}I\omega_f^2$

   C. $\frac{\tau\theta}{R} = \frac{1}{2}I\omega_f^2$

   D. $\tau\omega = \frac{1}{2}I\omega_f^2$

2. If a constant force of 10 N is applied to the edge of a thin ring with mass 10 kg and radius 10 m for 10 s, what will be its final angular speed?

   A. 10^{-1} $\frac{\text{rad}}{\text{s}}$

   B. 1 $\frac{\text{rad}}{\text{s}}$

   C. 10 $\frac{\text{rad}}{\text{s}}$

   D. 10^2 $\frac{\text{rad}}{\text{s}}$

3. **(AP Only)** Our sun will end it's life as a white dwarf. The white dwarf will have the mass of the sun, but a radius that is about 100 times smaller. The current rotational period of the sun is about 24 days. What would we expect the white dwarf's rational period to be?

   A. 24 days

   B. $\frac{1}{4}$ day

   C. 200 seconds

   D. 1 second

4. Why do you need a reminder to put your name on your paper?

   A. Alzheimer's

   B. I don't remember

   C. Reminders are for other people! My name is always written... oops.

[1] In the case of a circular orbit! For elliptical orbits, the r here is just the orbital radius. In non-circular motion, r changes and must be accounted for. This leads to the relation $m_1v_1r_1 = m_2v_2r_2$. None of this works for solid objects rotating.

5. How will the speed at which a sphere with radius R and mass M rolls down a ramp with light friction compare to the speed it slides down a frictionless ramp? Assume that the object does not deform or heat up.

   A. The same

   B. $\frac{2}{5}$ as fast

   C. $\sqrt{\frac{5}{7}}$ as fast

   D. $\sqrt{\frac{5}{2}}$ as fast

6. A planet is in an elliptical orbit. At it's closest, the planet is half as far away as at its furthest. What is the ratio of the speed at the furthest point to the speed at the closest point?

   A. $\frac{v_c}{v_f} = \frac{1}{4}$

   B. $\frac{v_c}{v_f} = \frac{1}{2}$

   C. $\frac{v_c}{v_f} = 2$

   D. $\frac{v_c}{v_f} = 4$

7. You have two solid metal spheres that are identical except that one has a radius exactly twice the other (with the same density).

   (a) What is the ratio of their moments of inertia?

      A. 4

      B. 8

      C. 16

      D. 32

   (b) (**AP Only**) The same force is applied to the equator of each sphere. What will be the ratio of the linear speed of a point on the equator of the larger sphere (v_L) to the linear speed of a point on the edge of the equator of the smaller sphere (v_s).

      A. $\frac{v_L}{v_s} = \frac{1}{4}$

      B. $\frac{v_L}{v_s} = \frac{1}{8}$

      C. $\frac{v_L}{v_s} = \frac{1}{16}$

      D. $\frac{v_L}{v_s} = \frac{1}{32}$

8. Could the following events occur? If so, write "Allowed", if not give which conservation law (choices: energy conservation, momentum conservation, angular momentum conservation) is violated and explain how. If more than one is violated, you may choose whichever you like.

   (a) A planet is in a circular orbit around an isolated star when it suddenly begins to spiral inward. It's orbital speed remains constant.

   (b) Two identical pizza crusts are thrown into the air rotating in opposite directions. They hit each other and stick together. At the end, they have no rotation.

   (c) Two asteroids rotating the same direction collide and break apart. Some of the pieces end up rotating more rapidly than the asteroids were initially in the same direction, and some end up rotating in the opposite direction as the asteroids were initially.

9. You are standing on a frictionless plane. Explain how you would turn around.

10. How do cats always land with their legs down?