# Homework 4

## PHYS 351, Fall 2021

This set contains 5 problems. In general, show your work. Please do your best to make it readable and clear. If it's a huge mess, it will be harder to understand your efforts. Each problem is worth the same amount. Partial credit will be given, so please attempt them all.

DUE: Dec 13, 12:00 pm, on paper, in class.

1. Consider an unusual system where orbiting bodies around a central force all move in circular orbits. The ratio of the periods of any two orbits is found to be equal to the ratio of their orbital radii *squared*. What is the dependance on distance for this central force?

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2. At the center of the milky way galaxy, stars have been observed orbiting a central point known as Sgr A*. One of the orbiting stars, known as S2, has been found to have a period of 16.05 years, a semi-major axis of 970 AU, and a periastron distance of 120 AU. Use those values and the basic properties of elliptical orbits to find:

    a. the orbital eccentricity of S2,

    b. the semi-minor axis of S2's orbit,

    c. and the mass of the central object that S2 is orbiting. Express this mass in multiples of our sun's mass.

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3. If we wanted to send a spacecraft to Neptune, a simple path would be a Hohmann transfer orbit between Earth and Neptune.

    a. Do the required math to figure how many years it would take to reach Neptune's orbit of 30 AU.

    b. Look up how long it took Voyager 2 to reach Neptune and explain briefly why that trip took a much shorter time.

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4. You drop a ball from the top of a long tower of height $h$ at the equator.

    a. Use the equation for the Coriolis force to determine if the ball will land either to the west or to the east of the base of the tower.

    b. Ignoring air-resistance, figure out an equation that relates the distance from the base of the tower to the point where it hits the ground in terms of Earth's rotating rate: $\omega$, the tower height $h$, and $g$.

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5. If you hold a bucket a water and spin it around the vertical axis, the water will start to creep up the sides. It actually make a parabolic shape. Show that this is the case by considering the surface of the water to be an equipotential surface under the combined effects of gravity and centrifugal forces.

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