PHYS 3344 Exam 2

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Printed Name ______________________________

DIRECTIONS:

1. If I can't read it, I can't grade it.

2. **Show** your work to receive credit.

3. **BOX YOUR FINAL ANSWERS**

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5. Paginate all pages. Label the problem number clearly.

6. Staple your pages together, in order.

7. Good luck.

Q1 10 pts. You observe an object with some mass m oscillating like a damped, one-dimensional simple harmonic oscillator in some fluid.. Carefully observing multiple oscillations, you notice that the equation of motion can be described by $x(t) = A\cos\omega_d t$, where A is some constant and the other quantities have their normal meanings. If the undamped resonance frequency of oscillation is ω_0, what is the magnitude of the frictional force F_N acting on the object as a function of m, A and ω_0?

Q2 15 pts. You are sitting at the very top of a frictionless spherical dome of radius R. From rest, you slide down the dome and at some point you leave the surface of the dome and go sailing off into the air, to the delight of small children who think they will get more Halloween candy if they can guess where you will land on the ground below. Somehow, they are aware that if they know the angle θ, measured from the vertical, at which you leave the dome, their chances will improve markedly. Hence, they need to find this angle. This is solvable by the methods of PHYS 1303.

a) 5 pts Determine your speed v as a function of height above the center of the dome. Box that answer.

b) 5 pts Use Newton's law and determine the normal force $\mathbf{F_N}$ the dome exerts on you. Indicate magnitude and direction. A sketch might help. Do not forget your box.

c) 5 pts Now determine the angle θ at which the normal force is zero and hence determine the angle at which you leave the dome.

Q3 10 pts. You notice that in some region of space, the only force acting on a particle of mass m is one which has the property that when the particle moves from one $\mathbf{r}_1$ to a new position $\mathbf{r}_2$, so that $\Delta\mathbf{r} = \mathbf{r}_2 - \mathbf{r}_1$ is along the direction of the force, its speed doubles. This is true regardless of the path the object follows from one position to the other. If the particle starts again from position $\mathbf{r}_1$ with its original speed v_0, but now travels to a new point $\mathbf{r}_3$ such that the distance $|\mathbf{r}_3 - \mathbf{r}_2| = |\mathbf{r}_2 - \mathbf{r}_1|$, and $\Delta\mathbf{r} = \mathbf{r}_3 - \mathbf{r}_1$ is along the direction of the force, what is the speed v_f of the particle at its new position?

Q4 5 pts. A uniform spherical asteroid of radius R_0 is spinning with angular velocity ω_0. As the ages past, it picks up more and more matter as it gravitationally attracts neighboring dust until its radius is R. For simplicity, assume that its mass density remains uniform and that the dust was originally at rest with respect to the asteroid (at least on average). Find the asteroid's new angular velocity ω. If you listen carefully, a Halloween goblin will remind you that the moment of inertia of a uniform sphere is $\frac{2}{5}MR^2$. Box that answer.

Q5 5 pts. A particle of mass m is subject to a force $\mathbf{F}(\mathbf{r}) = \eta r^{-k}\hat{\mathbf{r}}$, where η and k are constants and $\mathbf{r}$ is the radial position of the particle as measured from some origin. If the total mechanical energy E of this particle at radial distance $r = r_1$ is E_1, what is the total mechanical energy E_2 of this particle if the radial distance doubles $r = 2r_1$?

Q6 5 pts. Suppose you have 2 different planets but of identical mass in some solar system orbiting a star like our Sun. The central star provides the overwhelming majority of the gravitational force acting on each planet. You notice through your telescope that each planet sweeps out the same area in its orbit as the other in the same amount of time. That is, $dA_1/dt = dA_2/dt$. Since these planets have elliptical orbits, they speed up and slow down as they complete their respective orbits, just like Earth. Further observation shows that at their respective perigee (distance of closest approach to their sun), they each have the *same* angular velocity ω. If r_1 is the perigee distance for the planet with the smaller value perigee, what is the value of the perigee r_2 for the other planet? Do box that answer.