PHYS 3344 Exam 1

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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 15 pts. Suppose the Space-X people have a rocket of initial mass M_0 that ejects its burnt fuel at a constant rate $|dM/dt| = \mu$ and at a speed v_0 relative to the rocket.

a) 12 pts. Calculate the initial acceleration of the rocket if it starts vertically upward from its launch pad. Box your answer.

b) 3 pts. If the exhaust velocity of the gas with respect to the rocket $v_{ex} = 2000\,\mathrm{m/s}$, how many kilograms of fuel must be ejected per second to give this rocket, of mass 1000 metric tons, an initial upward acceleration equal to $0.5g$? It is OK to approximate g so that you can do the calculation in your head. Box your answer.

Q2 25 pts. Suppose you have some object moving horizontally through a viscous medium such the resistive force $\mathbf{F}_R$ depends on the third power of the velocity $\mathbf{F}_R = -\eta v^3 \hat{\mathbf{v}}$, where η is a constant and v is the speed of the object. Call the object's mass m. You can assume that initially the l speed of the object is v_0 and that it is headed to the right, along the positive x-axis. Box your answer.

a) 10 pts. Calculate the velocity $v(t)$ of the object as a function of time.

b) 10 pts. Now calculate the displacement $x(t)$ as a function of time. You can assume $x(t = 0) = 0$. **HINT:** Integrating $v(t)$, although tempting, may not be the easiest way to get the answer. A math trick you have used can be helpful. Box your answer.

c) 5 pts. What is $\lim_{t\to\infty} v(t)$? What is $\lim_{t\to\infty} x(t)$? Box your answers.

Q3 25 pts. You are on a strange planet with a strange atmosphere that produces a drag on projectiles that is *linear* with their velocity. You launch a softball of mass m with speed v_0 at an angle θ with respect to the horizontal. Go ahead and assume that the ball is launched from zero elevation and that gravity has the same value on this planet as on earth. The magnitude of the resistive $\mathbf{F}_R$ can be written as $F_R = \beta v$, where β is a constant.

a) 5 pts. Write Newton's 2nd law equation for the forces acting on the ball in the the x-direction **and** the y-direction. Call the horizontal direction the x-direction. Box your answer.

b) 15 pts. Solve both equations to come up with $\mathbf{v}(t)$, the velocity of the ball as a function of time. It is OK to write this function in vector component form so that you have one equation for the x-direction and another for the y-direction. Box your answers and be clear what equation refers to what direction.

c) 5 pts. At what time T_{max} does the ball reach its maximum height? Box your answer.