## Announcements

- CompDay 1 due tonight
- Homework 2 posted and due Monday
- I'm aiming to have scored and have feedback to you on HW1 by Friday
- Read through Ch 3.2 by Friday
- Responses: rembold-class.ddns.net



## Today's Objectives

- Writing sum of forces into velocity based differential equations
- Solving different types of simple differential equations
- Having some intuition about how quadratic drag behavesA
- Understanding how switching to complex numbers can help us with systems of equations



Friction could also be described as a force that opposes the direction of motion, except it is constant (assuming the normal force does not change). Consider a situation where a puck sits upon a table and is free to move about in the x and y plane. Friction, quadratic drag, gravity and the normal force are the forces present. What expression best describes the equation of motion in the  $\hat{x}$  direction?

A) 
$$m\dot{v}_x = -\mu N v_x \sqrt{v_x^2 + v_y^2} - c \sqrt{v_x^2 + v_y^2} v_x$$

B) 
$$m\dot{v}_x = \mu N \sqrt{v_x^2 + v_y^2} - c \sqrt{v_x^2 + v_y^2}$$

C) 
$$m\dot{v}_x = -\frac{\mu N v_y}{\sqrt{v_x^2 + v_y^2}} - c\sqrt{v_x^2 + v_y^2} v_y$$

D) 
$$m\dot{v}_{x} = -\frac{\mu N v_{x}}{\sqrt{v_{x}^{2} + v_{y}^{2}}} - c\sqrt{v_{x}^{2} + v_{y}^{2}}v_{x}$$



An object undergoes a drag force such that its equations of motion take the form:

$$\ddot{x} = -D\sqrt{v_x}$$

where D is a constant. If the object started with a speed of  $v_0$ , what expression describes the object's speed as a function of time?

A) 
$$\frac{(2\sqrt{v_0} - Dt)^2}{4}$$
B)  $\frac{-Dv_0^2}{2}$ 
C)  $\frac{(v_0 + Dt)^2}{2}$ 

B) 
$$\frac{-Dv_0^2}{2}$$

$$(v_0 + Dt)^2$$

$$D) \frac{(2\sqrt{v_0} - Dt)}{2}$$

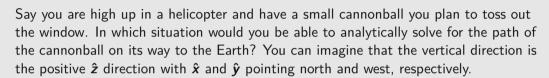




For linear drag, we saw that for two free falling objects with the same density, the larger object would hit the ground first assuming they started at a very high height. Suppose here you have two large cannonballs, each made of steel, such that quadratic drag will dominate. Ball A has a radius of twice Ball B. If they both fall far enough to reach terminal velocity, how much faster is Ball A traveling than Ball B when they hit the ground?

- A) The same speed
- B)  $\sqrt{2}$  times as fast
- 2 times as fast
- 4 times as fast





- A) Toss it out purely horizontally to the Northwest
- B) Toss it out slightly downward but due East
- C) Toss it out purely horizontally to the West
- D) None of the above



Suppose you have the coupled differential equations:

$$\dot{x} = -\frac{x}{2} + y$$

$$\dot{y} = -x - \frac{y}{2}$$

and want to combine both into a complex differential equation to better solve your problem. If  $\eta = x + iy$ , the equivalent complex differential equation would be:

$$\mathbf{A)} \ \dot{\boldsymbol{\eta}} = -(\frac{1}{2} + i)\boldsymbol{\eta}$$

$$\mathsf{B)} \ \dot{\eta} = -\frac{(1+i)}{2} \eta$$

C) 
$$\dot{\eta} = (i+2)\eta$$

D) One does not exist for this set of coupled equations