Forces and Kinematics

Full Name, Period: **due: x/xx**

1. You have a nonlinear spring that you believe behaves according to $F = -\beta x^{\alpha}$ where α and β are undetermined constant.

   (a) In terms of the constants gives, write an expression for the potential energy stored in the spring when it is expanded a distance d from equilibrium.

   (b) Design an experiment to determine both undetermined constants. Include a criteria that would cause you to reject the hypothesis that your prediction for the functional form was accurate.

   (c) Three groups run the experiment you designed and claim to get the following numbers. α is dimensionless, while β has units that are different between groups.

   - Group 1: $\alpha = 1.05$ and $\beta = 3.4$
   - Group 2: $\alpha = -1.01$ and $\beta = 2.8$
   - Group 3: $\alpha = 1.1$ and $\beta = -2.9$

   Can you immediately reject the claims of 1 or more groups? Explain your answer.

2. You have an object with mass m that is subject to gravity and a downward force $F >> mg$. Three of your friend are debating about the work done by gravity as the object falls some distance D. Their arguments are

   - The work done by a conservative force moving between two points is always the same, independent of anything else. Thus the work is just $W = mgd$ as expected.
   - That formula does not take into account the fact that the velocity is increasing. When the other force increases the velocity, that causes less than the expected time to be available for the force to act, so it does $W < mgd$.
   - Because the two forces act in the same direction, the power added by gravity is much larger than if the other force did not act. This means that $W > mgd$

   Who is correct, and why are the other two arguments wrong?

3. Consider a charged object with mass m that is in a time varying vertical electric field. The electric force on the charged particle is given by $\vec{F} = \alpha t^3 \hat{z}$ where $\alpha > 0$. Gravity is $\vec{g} = -g\hat{z}$.

   (a) Assuming we start from rest at some height z_0 at time $t = 0$, find the position $z(t)$.

   (b) Sketch a graph of the motion of the object. You do not need to label anything.

   (c) Determine how large z_0 must be if the object is to not hit the ground.

4. An object with mass m is traveling along the x axis in the positive direction with constant speed v. It has not yet reached $x = 0$. For all positive x, a field exists that provides a force of $F = -\alpha x^2$. How far does the object make it before it turns around?

5. An object is moving in an anticlockwise circle with a radius R with a speed $v = \gamma t^2$ where $\gamma > 0$. If you have a position of $\vec{r} = R\hat{x}$ at time $t = 0$, find the x and y positions as a function of time.