Problem Set 1

August 29, 2011

Setting up the mathematical problem to be solved given the verbal description is part of the skill being tested. However, setting up the problem is not considered to be the solution. Solving equations is another part of the skill being tested. The numerical estimate of the final question in each problem is also an important part of the solution. Draw figures.

Hand in the answers before September 6 to Ishan Mata. Answers given on or after September 6 will not be evaluated.

1. A pendulum is observed inside a smoothly accelerating truck. Set up the equations of motion in the frame fixed to the earth (the earth-fixed frame is assumed to be inertial), assuming that the pendulum only undergoes oscillations of small amplitude so that a quadratic approximation to the cosine is accurate. How does this differ from the equations of motion in the frame in which the truck is at rest? Do the two formulations give the same set of conserved quantities? Set up and solve the equations of motion. How can you find the acceleration of the truck using the pendulum? Assuming normal accuracies in the measurement of time periods, what is the fractional error that you will make in measuring the acceleration of a truck, assuming realistic ranges of acceleration?

2. A diwali rocket moves vertically against gravity by burning fuel at a fixed rate $\dot{\mu}$, which provides a vertical force F. If it starts from rest on the ground, what height does it reach? Assume that the maximum height reached is small enough that the acceleration due to gravity can be assumed constant. Take the initial mass to be M and the mass after all the fuel has burnt out in m. Set up the equations of motion and write them in dimensionless form. Solve the resulting equations and display the solution and the graph of the position, velocity and acceleration with time. Using this, estimate how high a realistic diwali rocket reaches.