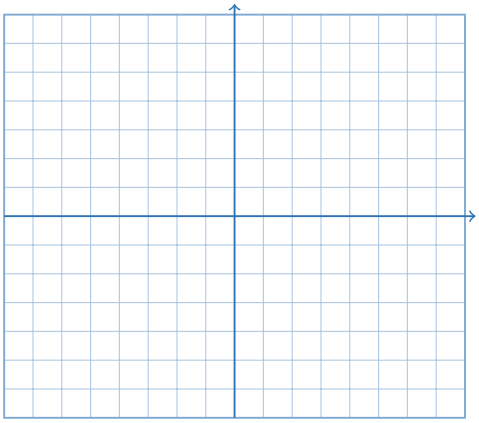
Problem Set 4: Work, Energy, and Power

Name: _____ **Date:** _____

Topics 3.1 through 3.5. Take $\vec{a}_g = -9.80665\,\hat{j}$ m/s^2. Name the system before you write an energy term, and say where you are putting the zero of potential energy. Out of 100 points.

1. A car of mass 1200 kg travels east along a straight level road at 15.0 m/s. A truck travels east along the same road at 20.0 m/s. (3.1) **[17 pts]**



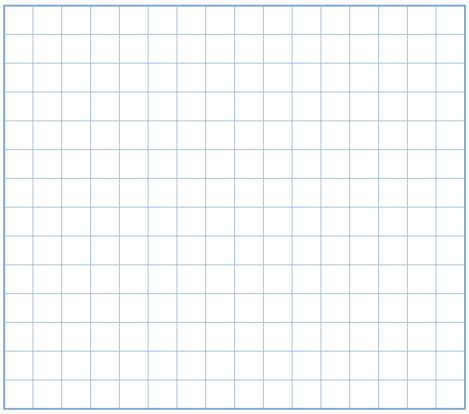
(a) Find the translational kinetic energy of the car as measured by an observer standing at the roadside. **[4 pts]**

(b) Find the translational kinetic energy of the car as measured by an observer riding in the truck, and say which of your two answers is the kinetic energy of the car. **[4 pts]**

(c) On the grid, to a stated scale, sketch the kinetic energy of the car against its speed for speeds from 0 to 30 m/s, and mark the two speeds above. **[4 pts]**

(d) A student says that because the truck goes one third faster than the car, the truck must have one third more kinetic energy. Write a short argument saying what is wrong with the claim, using both your graph and the equation, and state what else you would need to know before the two kinetic energies could be compared at all. **[5 pts]**

2. A crate of mass 25.0 kg is dragged 8.00 m across a level floor by a rope held at $30.0°$ above the horizontal. The tension in the rope is 90.0 N and the coefficient of kinetic friction between the crate and the floor is 0.250. (3.2) **[17 pts]**



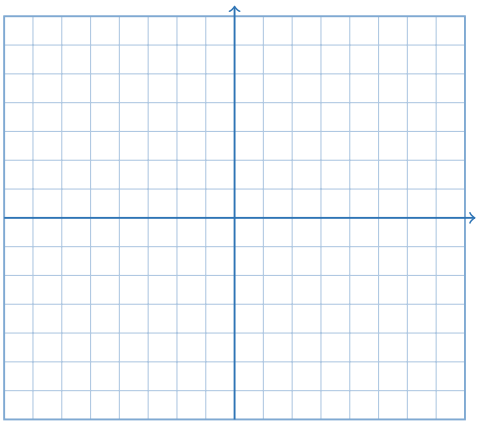
(a) Draw the free-body diagram of the crate on the grid, then find the work done on the crate by the rope. **[4 pts]**

(b) Find the normal force on the crate, and then the work done on the crate by friction. **[4 pts]**

(c) Find the work done on the crate by the gravitational force and by the normal force, and say in one sentence why each is what it is. **[4 pts]**

(d) The crate is now dragged 8.00 m out and 8.00 m back to where it started, with the rope at $30.0°$ to the direction of travel each way. Find the energy dissipated by friction over the whole trip and the work done by the gravitational force over the same trip, and use the two numbers to say which of those two forces can have a potential energy associated with it. **[5 pts]**

3. A block of mass 4.00 kg starts from rest on a level frictionless surface. A horizontal force is applied to it whose magnitude rises steadily from 0 at $x = 0$ to 20.0 N at $x = 3.00$ m, and then stays at 20.0 N out to $x = 5.00$ m. (3.2) **[16 pts]**



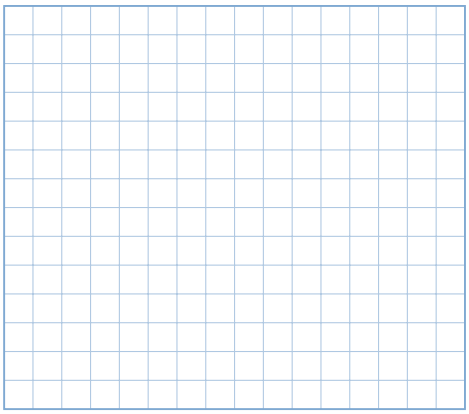
(a) Plot the magnitude of the force against position on the grid, to a stated scale, from $x = 0$ to $x = 5.00$ m. **[4 pts]**

(b) Find the work done by this force from $x = 0$ to $x = 3.00$ m, and then from $x = 3.00$ m to $x = 5.00$ m. **[4 pts]**

(c) Use the work-energy theorem to find the speed of the block at $x = 5.00$ m. **[4 pts]**

(d) The block now slides on a surface where friction dissipates 18.0 J over the same 5.00 m, with the same applied force. Find the new speed at $x = 5.00$ m, and say where the 18.0 J went. Do not write that it was lost. **[4 pts]**

4. A spring of stiffness 240 N/m stands upright on the floor with its top end 0.500 m above the floor. A ball of mass 0.800 kg is placed on top of the spring and pressed down until the spring is compressed by 0.120 m, then released. Air resistance is small enough to ignore. (3.3) **[17 pts]**



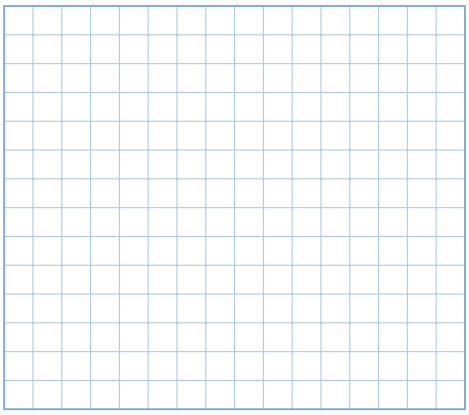
(a) Name the objects in the system you are going to use, and state where you are putting the zero of gravitational potential energy. **[4 pts]**

(b) Find the elastic potential energy stored in the system at maximum compression. **[4 pts]**

(c) Find the change in the gravitational potential energy of the system as the ball rises from the compressed position to the relaxed top of the spring. **[4 pts]**

(d) Find the greatest height above the floor that the ball reaches after it leaves the spring. Then say, in one sentence, how that height would have come out if you had put the zero of gravitational potential energy somewhere else, and why. **[5 pts]**

5. A block of mass 2.50 kg is released from rest at the top of a ramp whose top is 1.60 m above the bottom. **[16 pts]** The ramp is rough. The block arrives at the bottom moving at 4.20 m/s. (3.4)



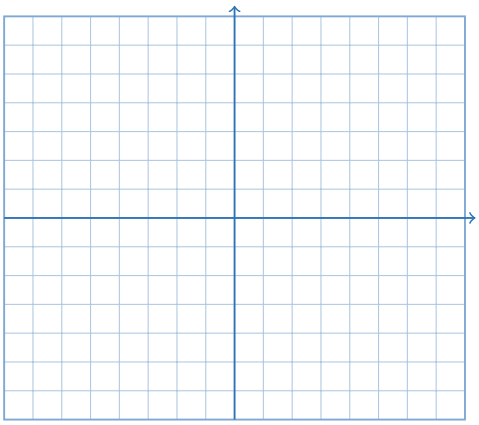
(a) On the grid, draw energy bar charts for the system of the block, the ramp and the Earth, one at the top and one at the bottom. **[4 pts]**

(b) Find the mechanical energy dissipated on the way down, and name where it went. **[4 pts]**

(c) Now take the system to be the block by itself. Say whether the total energy of that system stays constant, and name every force that does work on it. **[4 pts]**

(d) Write a short argument, in prose, explaining how one slide can be described by a system whose total energy is constant and by a system whose energy is not, with neither description being wrong. **[4 pts]**

6. An elevator cab of total mass 850 kg is raised by a cable through a height of 24.0 m at a constant speed of 1.80 m/s. (3.5) **[17 pts]**



(a) Find the tension in the cable, and the work the cable does on the cab over the 24.0 m. **[4 pts]**

(b) Find the average power delivered to the cab by the cable over that trip. **[4 pts]**

(c) Find the instantaneous power delivered by the cable at any moment during the climb, and say why it agrees with your answer to (b). **[4 pts]**

(d) The same cab is now raised the same 24.0 m in 9.00 s, starting at rest and finishing at rest. Find the average power delivered by the cable over that trip. Then explain, in a sentence, why the instantaneous power is not equal to that average at every moment, and sketch on the grid how you would expect the speed to run with time. **[5 pts]**