Physics 131 Spring 2006 Midterm Exam #1 Friday February 24, 8:30-9:25 am Harriman 137	**Name**:________________________________ Recitation section (circle one) (**1**) Mon. 11:45 (**2**) Wed. 9:35 (**3**) Tues. 12:50 (**4**) Wed. 11:45

Closed book. No notes allowed. Only **primitive** scientific calculators are permitted. There are no trick questions here. There are three questions, one per page, each worth 30 points, for a maximum score of 90. In general, you need to show the reasoning behind your answer. A correct number alone will not get much credit.

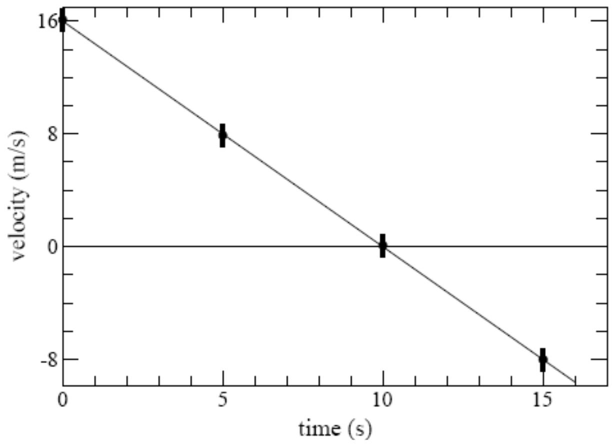
Do the exam on these pages. It would be smart to write your name on all 4 pages, in case of staple failure. If a question seems too easy, perhaps it is just easy. Relax and good luck! Two significant figures will be accepted as sufficient on this test. If your calculator is rejected by the proctors, or fails, you should get **numerical** answers to 10% by simple arithmetic for almost full credit. The **graded exams will be returned in recitation section next week**. If you feel that a problem should be regraded, explain this to your recitation instructor immediately after class. Your recitation instructor can then verify the complaint, and attach a note, and direct the exam to the appropriate grader. No regrading will be done unless this procedure is followed.

Physics 131 students have special permission from the registrar to switch into PHY 125 until the end of next week.

Turn cell phones off. Have your University ID out for checking, please.

Problem 1	
Problem 2	
Problem 3	
Total score	

1. A projectile is shot vertically upwards from the surface of the moon. The velocity v_y (with estimated errors indicated) is measured at various times t and plotted to the right. The positive direction is vertically upward.



   a. *(7 pt.)* At what time will the projectile return to the surface of the moon, and what will its velocity be then?
   b. *(8 pt.)* What is the magnitude g_M of the acceleration of gravity on the moon? Include an error estimate.
   c. *(8 pt.)* How high does the projectile go?
   d. *(7 pt.)* What is the position, velocity, and acceleration at t = 15 s?

answers

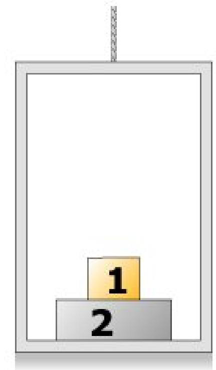
a. v_y on the way down is opposite to v_y on the way up at each elevation. Therefore since vy is 16 m/s when y=0 at the start, we know that v_y = -16 m/s when y=0 at the end. And it is clear by proportional times that this will happen at t = 20 s. Failure to specify the minus sign of v_y (or alternately to specify that it is down) will cost 2 points. Failure to give units will cost 1 point.

b. $\frac{\Delta v_y}{\Delta t} = a_y = \frac{-16m/s}{10s}$ =-1.6 m/s^2 . An appropriate error estimate is 1 m/s for Δv_y , or $\pm$0.1 m/s^2 for a_y.

c. 80 m, most simply found from an average upward velocity of 8 m/s for an interval of 10 s.

d. (y = 60 m, v_y = -8 m/s, and a_y = -1.6 m/s^2). The easiest way to find y is using the average v_y of 4 m/s for an interval of 15 s.

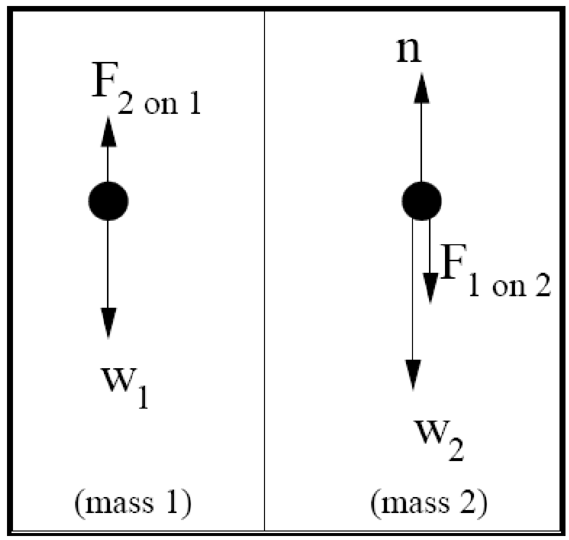
2. An elevator carries two blocks labeled 1 and 2, with masses m_1 = 20.0 kg and m_2 = 30.0 kg. The elevator is moving upwards, and its speed is decreasing at the rate 2.20 m/s^2. You will not get full credit unless you draw appropriate free body diagrams.
   a. *(5 pt.)* What is the earth's force on block 1? (This question always requires both direction and magnitude to be specified.)
   b. *(10 pt.)* What is the force exerted by block 2 on block 1?
   c. *(5 pt.)* What is the force exerted by block 1 on block 2?
   d. *(10 pt.)* What is the force exerted by block 2 on the floor of the elevator?



answers

a. $W_1 = m_1 g$ = 196 N

b. $F_{2\ on\ 1} - W_1 = m_1 a$ = -44 N. Therefore, $F_{2\ on\ 1}$ = 152 N. It's direction is upward, which should be specified, but if not specified, the combination of a drawing showing it upward, and a positive sign, should get full credit.



c. **Newton's third law** shows that it is equal and opposite, $F_{1\ on\ 2}$ = 152 N downward. Omitting "downward" and using instead a minus sign, would potentially contradict the picture showing $F_{1\ on\ 2}$ pointing down, but let's not get into the complications of this. However, either the words "Newton's 3rd Law" or an equation $\boldsymbol{F}_{1\ on\ 2} = -\boldsymbol{F}_{2\ on\ 1}$, or something like this, is needed by way of explanation.

d. This force is is the Newton's 3rd law opposite to the force called $\boldsymbol{n}$ in the diagram, and obeys $n - F_{1\ on\ 2} - W_2 = m_2 a$ = -66 N. From this it follows n = 380 N, so the force of block 2 on the floor is 380 N downward.

3. A pellet of mass m = 0.030 kg is fired vertically upward from the surface of the earth, using a spring gun. First the spring was compressed, storing U_0 = 20.0 J of potential energy.
    a. *(10 pt.)* How high will the pellet go if there is no loss of energy to friction?
    b. *(5 pt.)* How much work did the spring do when it was compressed?
    c. *(5 pt.)* How much work did the earth's gravity do during the upward part of the motion?
    d. *(10 pt.)* Suppose there is friction between the pellet and the gun bore, and that the path length of the pellet in the gun bore is 0.050 m. How big is the frictional force if the height of the path is 3/4 of the ideal frictionless answer?

Answers

a. The stored spring energy 20 J will all go to gravitational potential energy *mgh*, so h = 68 m.
b. The spring did –20 J of work. This follows from the definition of the potential energy of a force as the negative of the work done by the force (when the force is conservative.)
c. Similarly the earth's gravity did -20 J of work. An alternate explanation of the minus sign, in both (b and c), of course, is that the force of the (spring, earth) is opposite to the displacement.
d. 5 J which otherwise would have been turned into gravitational potential energy is now lost because of frictional work. In other words, friction did – 5J of work. This corresponds to a force of 5 J/0.05 m, or 100 N directed along the bore of the gun, opposite to upward motion of the pellet.