SKILLS NEEDED FOR THE FIRST NOVEMBER TEST (L-H, 1999)

1. Calculate with quantities which have uncertainties and units. Give the units, MLV, GLV, SLV, range, absolute uncertainty, or percentage uncertainty of the result as on previous tests. (Use #16-19 on RS I or #25-26 on RS II.)

2. Use the definition of "slope" on RS I. Determine the slope of a linear graph as in #7 on RSI. Determine the units and uncertainty of such a slope as on page 16 and as on previous tests.

3. Calculate the area of any given rectangle, triangle, trapezoid, or circle. Given two similar triangles and given the ratio of their areas, calculate the ratio of their heights or widths. Given the ratio of their heights, calculate the ratio of their areas. (See page 31R)

4. Identify the graph of any familiar equation as on page 16 and the back of RS II. Create an equation to describe a given set of data, as on pages 16, 16R, and 18.

5. Given a verbal description of a graph, draw the graph. Use common sense to decide whether or not such a graph can cross the axes. Sketch a velocity-time graph or a displacement-time graph to describe any familiar motion, as on page 17c.

6. Draw a tangent line at a given point on a curve, as on page 29.

7. Use the definitions of "acceleration", "velocity", "change in velocity", and "average velocity" as recorded on RS I, RS II, and RS III. Also use the definition of "uniform acceleration".

8. Solve motion problems by the procedure on your chapter review sheet. Determine the distance travelled by a moving object during a given time interval by the method in #2 on RS II.

9. Given a graph of displacement vs time or velocity vs time, determine which parts describe positive acceleration and which describe negative acceleration as on pages 27, 29, and 34.

10. Use the relation between weight and mass in #8 & #9 on RS III.
Use the definition of gravitational field strength on pages 6, 32, 35, RS I, and RS III.

11. Use vector addition as on pages 30, 34, 34R, and 36. Describe the direction of a resultant by the method on page 34 & 34R. Predict the uphill force needed to prevent something from rolling down a ramp, as on page 36.

12. Draw a vector triangle with precision better than one percent, as in #12 on RS III.

13. Solve routine proportion problems and "fractional change" problems as on page 19, 20, 21, & 22. Given the percentage change in one variable, predict the percentage change in another.

14. Given all of the forces acting on an object, predict the direction of the object's acceleration as on pages 32, 33, and in #4 on RS III.

15. Determine the direction of an object's acceleration by comparing its apparent weight to its actual weight, as on pages 33 & 34. (Use #5 on RS III.)

16. Use an object's displacement-time graph to determine the direction of its velocity or acceleration and to sketch its velocity-time graph, as on page 33.

17. Use Hooke's equation, as on page 33.

18. Use dimensional analysis to figure out an unknown unit or exponent in an equation as we did on pages 6, 9, 12R, and 18.

19. Round off a number properly, as on page 14. (Keep only one bogus digit.)

First November Test (Level H, 1999) **name**_____

1. Moving a pendulum to a planet with weaker gravity would cause its bob to have *less* acceleration after release, so that it would need *more* time to complete one swing.
   a. Use that clue to sketch a graph of pendulum period vs gravitational field strength. (sk. 5)
   b. If you had to guess about the equation which describes that graph, what would be your first guess? Write your guess in proportion language, using "P" and "g". (skill 4)

2. There must be an equation for predicting the period of a pendulum. The right side of that equation must have a proportionality constant and two variables with exponents. Use sk. 4:
   a. We know that one of those variables is the *length* of the pendulum. What is its exponent?
   b. According to #1 above, the other variable must be "g", which can be measured in *acceleration* units. What exponent must that variable have? Clues: The units must balance in the equation, and the proportionality constant has no units. (skill 18)

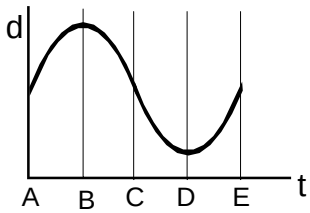
3. While riding southward at 30 ft/sec, Bart shoots a spitball to his right at 40 ft/sec relative to the bus. With what velocity does the spitball strike his cousin O.J., who is standing on the sidewalk? *Give its speed and the direction of its motion.* (11, 12)

4. Bart's bus then brakes uniformly from 40 ft/sec to a complete stop in 6.0 seconds.
   a. How far does it go while stopping? (skill 8)
   b. How far does it go during the first 3.0 seconds of braking? (skills 3, 8)
   c. The given speed has an uncertainty of ± 0.1 ft/s. The uncertainty of the given time interval is ± 2 %. Calculate the relative uncertainty of the distance found in 4a. (skill 1)

5. A 750-meter segment of string is wound neatly into a solid ball with uniform density. The diameter of this ball of string is 12 centimeters. If I unwind 450 meters of string from the ball, what diameter will the remaining ball of string have? (skills 13, 18)

6. Your job is to prevent a rich guy's fancy car from rolling downhill. It has no brakes and no parking gear, and he is far too busy to get it fixed. How hard must you push uphill if the weight of the car is 2000 pounds and the inclination angle is 10.0 degrees? (skills11,12)

7. The displacement vs time graph sketched below describes the motion of an object bobbing up and down on a spring. Upward vectors are represented by positive numbers here.
   a. The graph shows that the object's velocity is negative (downward) in what time interval? Give *two* letters to indicate the beginning and end of the *longest* time interval which correctly answers the question. (skills 6, 7)
   b. Sketch the corresponding graph of velocity vs time. (It's also curved.) Label the special points on its time axis, as on the given graph. (skills 5, 16)
   c. During what time interval does the object have downward acceleration? Again, please give the *longest* correct interval. (skill 7)
   d. During the interval described in 7c the upward force exerted on the object by the spring was not equal to the downward gravitational force on the object. Which was stronger? (skills 15,16)
   e. Sketch the graph of spring tension vs time. Label the special points on the time axis, as in the previous two graphs. (17)



8. Homer drove west at 60 mph between 2:00 PM and 4:00 PM. Then he turned and drove north at 80 mph between 4 PM and 6:00 PM.
   a. Describe his average velocity in vector language. (Use skills 7, 11.)
   b. Describe his *change* in velocity in similar fashion. (skill 7)

9. Estimate the speed with which a strand of your hair grows. Start by thinking about how much it grows between haircuts. Choose one of the following *or* write your own estimate in similar form. A. Between 10^{-2} and 10^{-3} m/sec. B. Between 10^{-1} and 10^{-2} m/sec.

10. Did you round off each numerical answer properly on this test? (skill 19)

ANSWER SPACE

1a)

1b)

2a)

2b)

3)

4a)

4b)

4c)

5)

6)

7a)

7b)

7c)

7d)

7e)

8a)

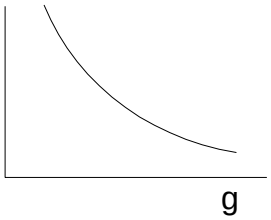
8b)

9)

10)

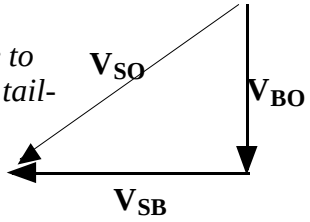
First November Test Solutions (Level H, 1999)

1. In weaker gravity a pendulum bob needs *more* time to complete one swing.
   a. Use that clue to sketch a graph of pendulum period vs gravitational field strength.
   Clearly the graph must have negative slope but cannot cross either axis.
   b. If you had to guess about the equation which describes that graph, what would be your first guess? (in proportion language, using "P" and "g")
   The graph resembles y = 1/x, so maybe ***P ∝ 1/g.***



2. There must be an equation for predicting the period of a pendulum with two variables on the right side.
   a. We know that one of those variables is the *length* of the pendulum. What is its exponent?
   We know from #18 on RS II (and from page 18) that pendulum period is proportional to the square root of length, so the exponent is ***1/2***.
   b. According to #1, the other variable must be "g". What exponent must that variable have?
   The given information says $P \propto L^{1/2} g^x$, *where "x" is the unknown exponent*
   Since the units must balance in the equation, and the proportionality constant has no units, we conclude that $(sec) = (meter)^{1/2}(m/s^2)^x$. *The only x-value that can make that equation balance is* ***-1/2***.

3. While riding southward in a bus at 30 ft/sec, Bart shoots a spitball to his right at 40 ft/sec relative to the bus. With what velocity does the spitball strike his cousin O.J., standing on the sidewalk?
   The velocity of the spitball relative to OJ is equal to the velocity of the spitball relative to Bart plus the velocity of Bart relative to OJ. ($V_{SO} = V_{SB} + V_{BO}$) *Adding those vectors tail-to-head, we get a 3-4-5 triangle. Therefore* V_{SO} = ***50 ft/sec, 53º West from South.***



4. Bart's bus then brakes uniformly from 40 ft/sec to a complete stop in 6.0 seconds.
   a. How far does it go while stopping? *The speed-time graph is a triangle with height = 40 ft/s and width = 6.0 s. The stopping distance is the area of that triangle:* $D = (40 ft/s)(6.0 s)/2$ = ***120 ft.***
   b. How far does it go during the first 3.0 seconds of braking? *The left half of the triangular speed-time graph is a trapezoid with heights of 40 and 20 ft/s, and width = 3 sec. Its area is average height x width:*

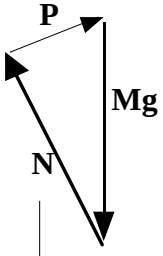
$$D = (3 sec)(40 + 20 ft/s)/2 = \textbf{90 feet}$$

   c. The given speed has an uncertainty of ± 0.1 ft/s; the time interval is ± 2 %. Calculate the relative uncertainty of the distance in 4a. *The relative uncertainty of the speed is (± 0.1 ft/s)/(40 ft/s) = ± 0.25%. To get the distance in 4a we multiplied, so we must add the relative uncertainties of the factors.*

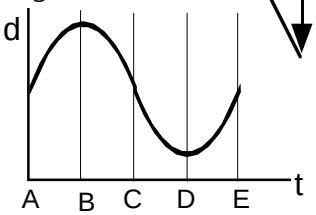
$$2\% + 0.25\% = \textbf{± 2.25\%}$$

5. A 750-meter segment of string is wound into a ball. The diameter is 12 cm. If I remove 450 meters of string what diameter will the remaining ball have? *Let* V_2 = *new volume, and* V_1 = *original volume of the ball. We know that* $V_2/V_1 = 450/750 = 0.6$. *We also know (from the units) that volume must be proportional to diameter cubed:* $V_2/V_1 = (D_2/D_1)^3$, *so* $D_2 = D_1(V_2/V_1)^{1/3} = (12 cm)(0.6)^{1/3}$ = ***10.1 cm.***

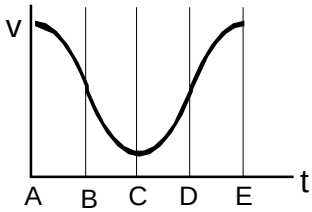
6. Your job is to prevent a rich guy's fancy car from rolling downhill. How hard must you push if the weight of the car is 2000 pd. and the inclination angle is 10.0 deg? *The total force on the car must be zero, so the three forces placed head-to-tail must form a triangle. Mg is downward, N is perpendicular to the road, and P is uphill. N must be perpendicular to P, and the angle between N and mg must be 10 deg. So* $P = mg \sin(10^o) = (2000 pd)(0.1736)$ = ***347 pd.***



7. The given displacement vs time graph describes the motion of an object bobbing up and down on a spring. Upward vectors are represented by positive numbers.



   a. The graph shows that the object's velocity is negative (downward) in what time interval? *Velocity is the slope of a D-t graph.*
   This graph has negative slope in the time interval between ***B and D.***



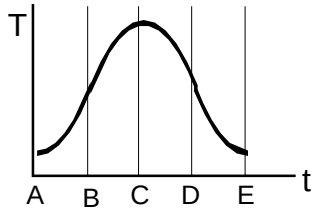
   b. Sketch the corresponding graph of velocity vs time. (It's also curved.) Label the special points on its time axis, as on the given graph. (skills 5, 16)

   c. During what time interval does the object have downward acceleration?
   The V-t graph has negative slope ***between A and C.***

First November Test Solutions (Level H, 1999) continued

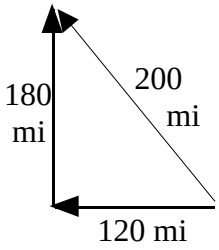
d. During the interval described in 7c the upward force exerted on the object by the spring was not equal to the downward gravitational force on the object. Which was stronger?
The object can have downward acceleration only if the ***downward force is stronger than the upward force.***

e. Sketch and label the graph of spring tension vs time.
Tension is proportional to amount of stretch, which is greatest at D and smallest at B, according to the given graph.

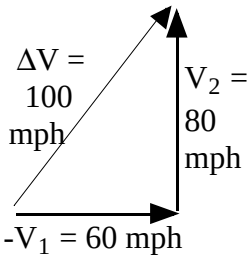


8. Homer drove west at 60 mph between 2:00 PM and 4:00 PM. Then he turned and drove north at 80 mph between 4 PM and 6:00 PM.

a. Describe his average velocity in vector language.
He went 120 miles west, (60 mph x 2 hr) and then 160 miles north. Drawing an arrow from his starting point to his ending point completes a 3-4-5 triangle. So his overall change in location (displacement) is 200 miles, 37 deg west from north. His average velocity is that change in displacement divided by the 4-hour time interval, or ***50 mph, 53 deg north from west.***



b. Describe his *change* in velocity in similar fashion. (skill 7)
Now we must subtract the first velocity from the second. That means we must reverse the first velocity and then add it (tail-to-head) to the second velocity. We get a new 3-4-5 triangle which shows that his change in velocity is ***100 mph, 53 deg north from east.***



9. Estimate the speed with which a strand of your hair grows.
I cut off about one cm every two weeks. Converting that time interval to SI,
(14 days)(24 hr/day)(0.36 x 10^4 sec/hr) = more than 10^6 sec. One cm. is 10^{-2} m.
To get the speed I must divide the distance by the time interval:
(10^{-2} m)/(more than 10^6 sec) = less than10^{-8} m/s, or ***between 10^{-9} and 10^{-8} m/s***

10. Did you round off each numerical answer properly on this test?

Actually, the given uncertainties in 4c had only one significant digit, so I was foolish to keep three digits in my answer. The diameter given in #5 apparently had two significant digits, so keeping a third digit in the final answer is acceptable even though the third digit should not be trusted. The given weight of the car in #6 appears to have been rounded off to one digit, so I should have rounded off my answer to 350 pd.