

Print your Name:

1	2	3	4	5	Total	Grade
6	9	6	8	11	40	100

**Physics 1422
Exam 1**

**General Physics I-A
February 8, 2006**

All numerical answers require an explanation for credit, which must show symbolically any formulas you used. Numerical results must include correct units for full credit. Non-numerical answers (multiple-choice or pictures) require an explanation only if one is explicitly requested. Answers and explanations must be legible for credit. Verbal explanations after the exam will not add points to your score.

Only work on the front of the page will be graded. You may use the backs of the pages as private scratch space to plan your strategy. This may help you write more readable calculations, which will maximize partial credit. In the event of a wrong answer, more partial credit can usually be assigned to an algebraic solution than a purely numerical one. Try not to do all the work on your calculator.

If you are not sure how to work a problem in terms of formulas, or do not have time to do so, a good verbal analysis may receive partial credit. If you need a result from an earlier part of a problem to work a later part, but do not have it, an algebraic solution will receive most of the credit.

Useful Relations

Mass and weight conversions:

$$1 \text{ g} = 6.02 \times 10^{23} \text{ amu} \tag{1}$$

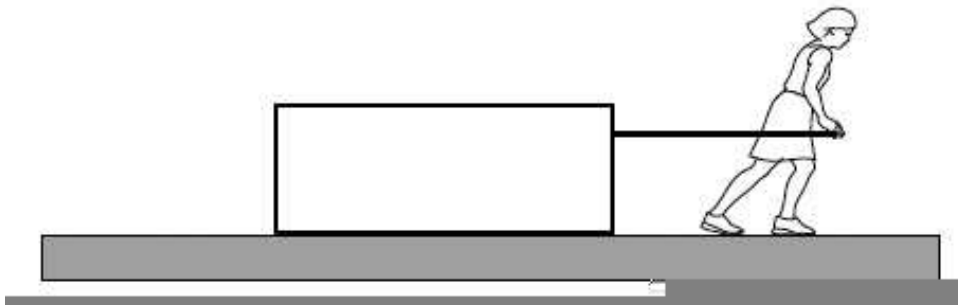
$$1 \text{ kg weighs } 9.8 \text{ N on Earth} \tag{2}$$

Acceleration of gravity:

$$g = 9.8 \text{ m/s}^2 = 32 \text{ ft/s}^2.$$

Velocity conversions: $1 \text{ m/s} = 3.60 \text{ km/hr}$, $1 \text{ mi/hr} = 1.61 \text{ km/hr}$, $1 \text{ knot} = 1.85 \text{ km/hr}$

1. [6pt] A woman pulls a large box across the floor at a constant speed v as shown in the figure, applying a constant horizontal force F to the box. When the woman first started pulling the box, it began at rest.



Mark each statement T for true or F for false.

- 1) ____ The woman must have applied a force greater than F to start the box moving from rest.
 - 2) ____ While the box was accelerating from rest to speed v , the frictional force of the woman's shoes against the floor was greater than the frictional force of the box sliding on the floor.
 - 3) ____ While the box is moving at the constant speed v , the frictional force on the box has magnitude F .
 - 4) ____ While the box was accelerating, the woman had to pull on the box with a larger force than the box pulled back on her.
 - 5) ____ If the woman tipped the box up on its end, so that only half as much surface area were in contact with the floor, she could pull it with less force.
 - 6) ____ If the woman suddenly stops pulling the box, it will immediately stop moving.
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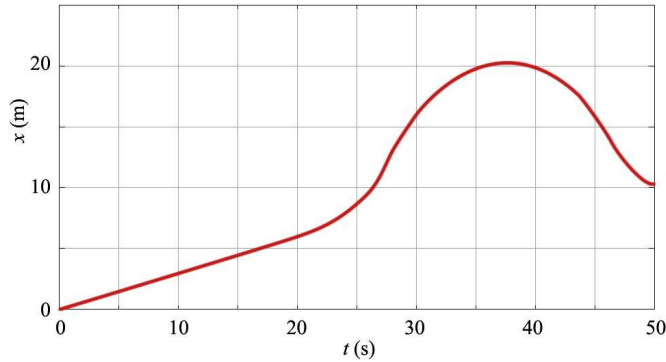
2. [9pt] Water has a density of 1 g/cm^3 and water molecules have a mass of 18 amu.

(a) [3pt] How many water molecules are in 1 cm^3 ?

(b) [3pt] How much volume (in cm^3) is occupied by a single water molecule?

(c) [3pt] Use this result to estimate the width of a single water molecule.

3. [6pt] A rabbit runs through a pipe, and the space-time graph is as shown in the figure.



Match each description to one of the velocities labeled A – H. Enter the label for the best match on the line next to the appropriate description. No answer is used twice, and some of the answers are not used at all.

- | | | |
|---|---------------|--------------|
| 1) ___ Instantaneous velocity at $t = 10$ s | A. -1.0 m/s | E. 0.6 m/s |
| 2) ___ Instantaneous velocity at $t = 38$ s | B. 0 m/s | F. 1.0 m/s |
| 3) ___ Maximum instantaneous velocity | C. 0.2 m/s | G. 2.5 m/s |
| 4) ___ Average velocity between $t = 40$ s and $t = 50$ s | D. 0.3 m/s | H. 4.0 m/s |
| 5) ___ Average velocity for the entire trip | | |
| 6) ___ Average speed for the entire trip | | |

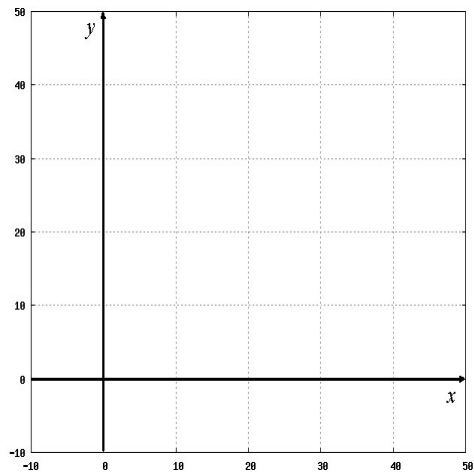
4. [8pt] Relative to an observer at the origin, a ship is seen at a position described by a vector $\mathbf{R} = (30 \text{ km})\mathbf{i}$. The ship has a constant velocity

$$\mathbf{v} = (12 \text{ knots})\mathbf{j} - (16 \text{ knots})\mathbf{i}.$$

Here, \mathbf{i} and \mathbf{j} are unit vectors pointing to the right and upward, respectively.

(a) [2pt] Draw a dot on the graph at the position of the ship, and draw a line showing its path. Be as accurate as possible.

(b) [3pt] What is the ship's speed (in knots) and direction (angle θ relative to the $+x$ axis)?

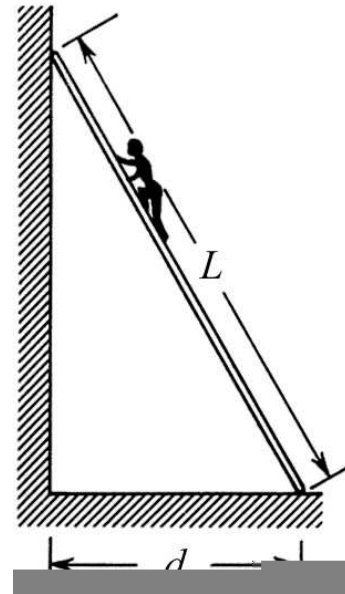


(c) [3pt] Find the distance of closest approach. (Full credit requires a calculation. You can get half credit without a calculation, by showing the geometry of the solution on the graph and estimating this distance.)

5. [11pt] A 90 kg painter is climbing a 5.0 kg ladder with a length of $L = 5.0$ m, set with its base a distance $d = 3.0$ m from the wall. The ladder will slide if the horizontal force exceeds 550 N. Assume the wall is very smooth (negligible friction).

(a) [2pt] On the diagram, show all forces acting on the ladder, at the location where they act. Label the forces. (This is an isolation diagram, or free-body diagram, for the ladder.)

(b) [3pt] What is the torque about the base of the ladder due to the weight of the ladder? Is it clockwise or counterclockwise?



(c) [3pt] What is the torque about the base of the ladder due to the wall pressing on the ladder, if it is just about to slip? Is it clockwise or counterclockwise?

(d) [3pt] How high can the painter climb the ladder without it slipping?