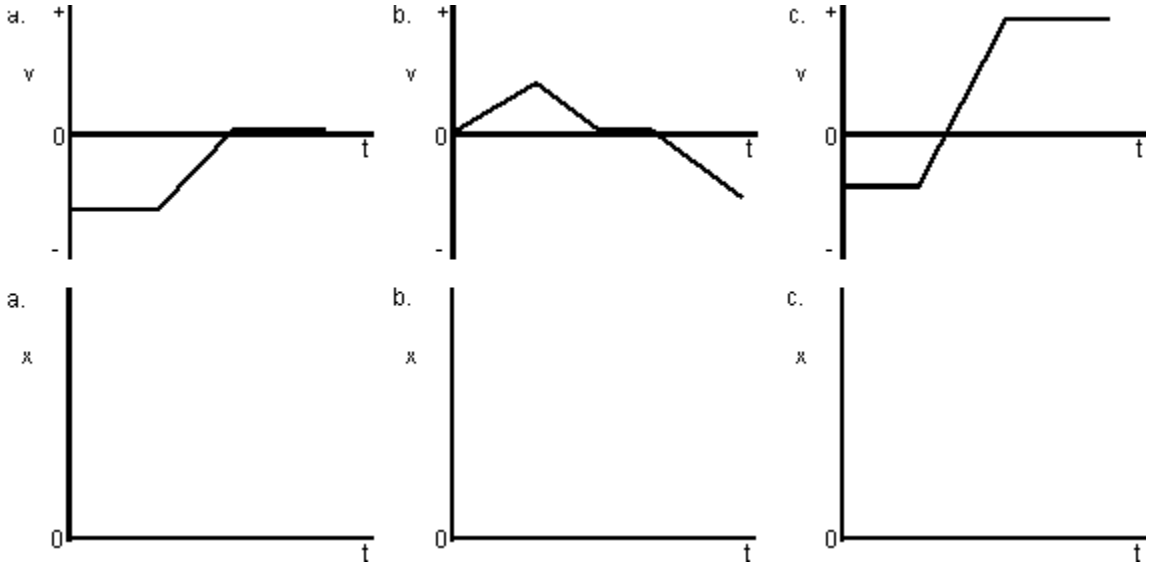
Try-Math-A-Lon
Fall Regional Competition
Engineering Contest 2008

Team Name:_____

The Engineering Test (TEC) Directions:

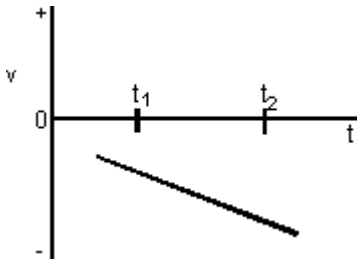
This test is to be taken as a team, and is used as a Physics assessment. Calculators are allowed. Each question is worth 10 points. **You have 60 minutes to complete problems 1-5.** (Show all of your work).

Problem 1. Given the following velocity-time graphs, sketch corresponding position-time graphs. Explain why you drew each part of each graph as you did.



Problem 2: Calculate the wavelength in a vacuum of a radio wave having a frequency of $2.2 \cdot 10^6$ hertz. [Show all work, including the equation and substitution with units.] hint: c = 3.0 x 10^8

Problem 3. Answer the following questions for the interval t_1 to t_2 based on the velocity-time graph.



a. Is the velocity positive, negative or zero? Explain.

b. Is the velocity increasing, decreasing or not changing? Explain.

c. Is the acceleration positive, negative or zero? Explain.

d. Is the acceleration increasing, decreasing or constant? Explain.

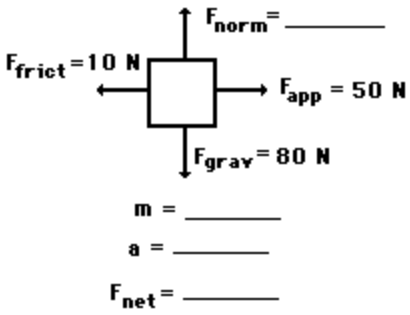
e. Is the displacement for the time interval positive, negative or zero? Explain.

f. Is the position increasing, decreasing or zero? Explain.

g. Is the position positive, negative or zero? Explain.

h. Describe a motion consistent with this graph.

Problem 4: An applied force of 50 N is used to accelerate an object to the right across a frictional surface. The object encounters 10 N of friction. Use the diagram to determine the normal force, the net force, the mass, and the acceleration of the object. (Neglect air resistance.) hint:To simplify calculations, an approximated value of g is - 10 m/s/s.



Problem 5:

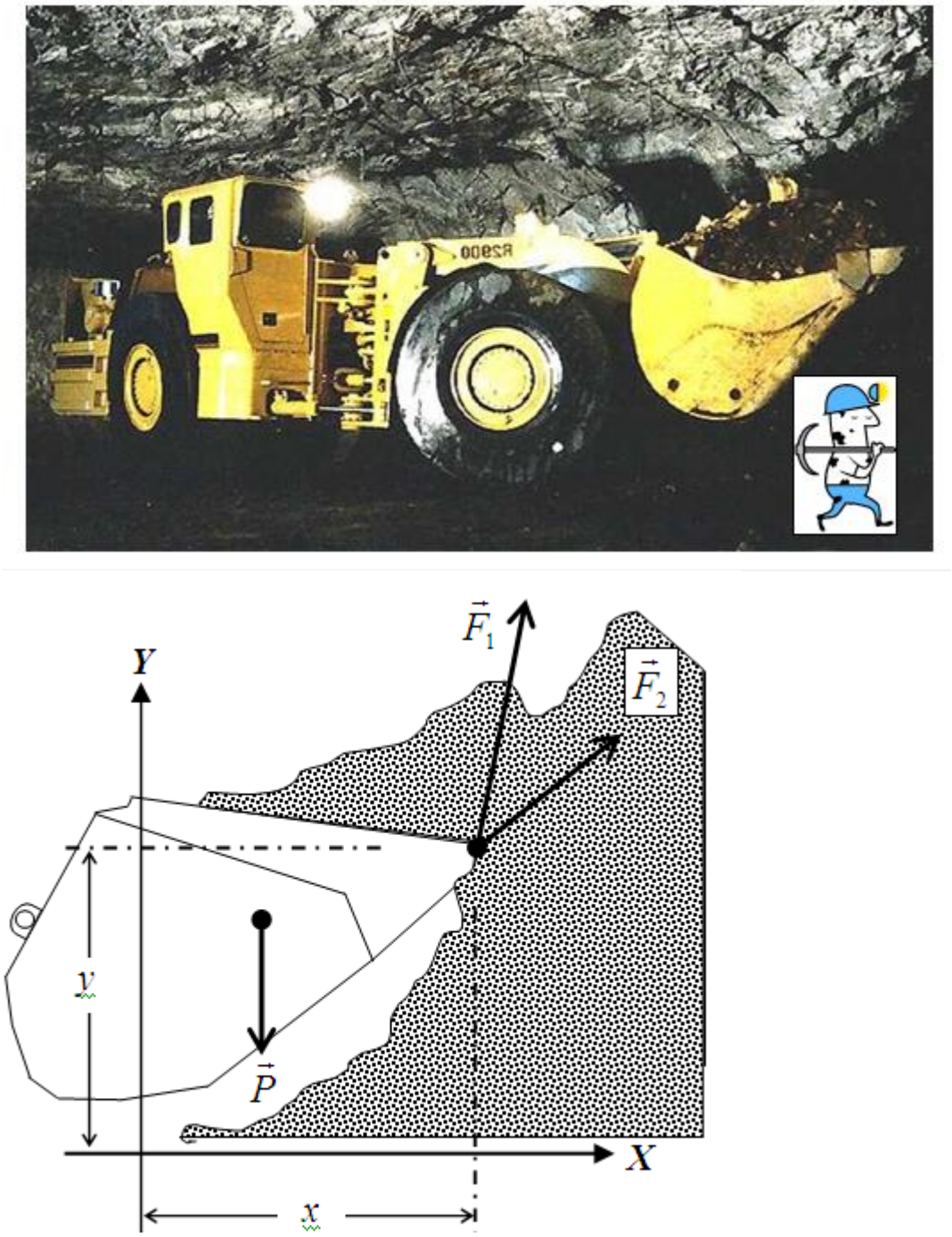


Figure 1:

Problem A: Computing the Volume of the bucket

The excavator used in this study has a maximum capacity of 3 metric tones that includes the weight of the empty bucket plus the weight of material. Assuming that the empty bucket weights 25% of its total maximum load, compute in m^3 the volume of the bucket based on a full load of wet earth with a density of 2,698 lb/yd^3.

As shown on figure 1, several forces act on the bucket during the scooping process. The main once represented here are:

- $\vec{P}$ The weight of the bucket and rock in it;
- $\vec{F}_1$ The pressure exerted by the pile of material inside the bucket;
- $\vec{F}_2$ The cutting and the friction resulting force on the edge of the bucket.

To simplify the study of these forces, each of them is decomposed into two main components: one horizontal on the ***X***-axis and a vertical one on the ***Y***-axis. The resulting force on the X-axis is named $\boldsymbol{F}_x$ and on the ***Y***-axis $\boldsymbol{F}_y$. A model of these two forces is given as follows:

$$\begin{cases} F_x(x) = \dfrac{k_x}{1+(x^2-0.25)^4} \\ F_y(y) = k_y \left(b_3\sigma^3 + b_2\sigma^2 + b_1\sigma + b_0 \right) \end{cases} \qquad \text{(eq. II.1)}$$

Where σ is a variable and $b_{0\ldots3}$, k_x and k_y are constants to be determined later.

Problem B: Computing the maximum forces on ***X***-axis

The maximum value of $F_x(x)$ is found by solving the following equation:

$$8x(x^2 - 0.25)^3 = 0 \qquad \text{(eq.II.2)}$$

Considering that the pile of material starts a $x = 0$ find the value of *x* that leads to the maximum value of F_x for $k_x = 10000\ N$. Justify your selection and compute the resulting value of F_x .