Print your full name: ________________________________________________

Sign your name: _________________________________________________

Please fill in your Student ID number: __ __ __ __ __ __ __ __ __ __

IMPORTANT

Read these directions carefully:

• There are 5 problems totalling 75 points. Check your exam to make sure you have all the pages. Work each problem on the page the problem is on. You may use the back. If you need extra pages, I have plenty up front.

• **Indicate what you are doing!** We cannot give full credit for merely writing down the answer. **Neatness counts!** I will give generous partial credit if I can tell that you are on the right track. This means you must be neat and organized.

• Each problem with its associated figure is self explanatory. If you must ask a question, then come to the front, being as discrete as possible so as not to disturb others.

• Put your name on each page it is asked for. You will lose credit if you fail to print your name on each page it is asked for.
The velocity of a particle moving in 1 dimension is plotted below. Initially, the particle is at rest. It then speeds up until it reaches 10 m/s at $t = 10$ seconds. It then holds this speed.

This behavior is plotted here:

(a) (5 points) Calculate the acceleration of the particle at $t = 5$ s and $t = 15$ s.
(b) (10 points) Calculate the total distance covered by the particle during the first 15 seconds.
Problem 2. 15 points.

Suppose a particle moving in one dimension has position given by

\[ x(t) = x_0 + A t^{3/2} - \frac{1}{3} C t^3 \]

where \( x_0, B, \) and \( C \) are given constants.

Calculate the velocity and acceleration of the particle as functions of time.
Problem 3. 15 points.

Consider a particle moving in one dimension. The particle starts at position \( x_0 = 0 \), with a positive initial velocity \( v_0 \) which is given. The acceleration of the particle is given by

\[
a(t) = -A t
\]

where \( A \) is a given positive constant. Note that the particle is decelerating.

Derive equations for the position and velocity of the particle as functions of time.
Consider the particle in the previous problem. If you worked the problem correctly, the position as a function of time looks like this:

You see that the particle initially moves in the positive direction, but then reaches some maximum position and then moves backwards, eventually moving through its starting point and continuing on backwards.

(a) Calculate the maximum position.

(b) Calculate the velocity of the particle when it returns to its initial position.

Express both of these answers in terms of $v_0$ and $A$ and some numerical factors. There should be no other symbols in the answer.
Problem 5. 15 points.

A projectile is fired from the top of a cliff as shown in the figure. The projectile is fired with initial velocity $v_0$ at an angle $\theta$ above the horizontal. The particle hits the ground a distance $R$ from the bottom of the cliff.

Calculate the height of the cliff $H$. Express your answer in terms of $R$, $v_0$, $\theta$, and $g$. 
You may remove this sheet.

If you do remove this sheet,

**DO NOT TURN IT IN!**

Potentially useful equations

**Calculus:**

**Derivatives:**

If \( x(t) = C t^n \) then \( \frac{dx}{dt} = C n t^{n-1} \)

**Integrals:**

\[
\int_{t_1}^{t_2} C t^n \, dt = C \left[ \frac{t_2^{n+1}}{n+1} - \frac{t_1^{n+1}}{n+1} \right]
\]

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