INSTRUCTIONS:
• PRINT YOUR NAME at the top of each page of this exam book.
• On your Scantron form, WRITE your name and perm number, BUBBLE in your perm number, and WRITE the day and time for your discussion section.
• There are 5 multiple-choice questions (worth a total of 20 points) and two free-response problems (worth 40 points each) on this exam. For the multiple-choice questions, bubble in the one best answer on your Scantron form and circle the one best answer on your exam book.
• Do your work for the free-response problems in this exam book. For full credit, be sure that you show your work, simplify your answer, and draw a box around each answer.
• This is an open book, open notes exam. Calculators and mobile devices of any kind are forbidden.
• If you have any questions during the exam, please ask the instructor or TA.

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(Your score on the multiple-choice questions will be posted on GauchoSpace.)
MULTIPLE-CHOICE QUESTIONS (20 points). For each of these 5 questions, bubble in the one best answer on your Scantron form AND circle the one best answer on this exam book. Make certain that you do both!

1. Consider the vectors shown. What is the cross product $\mathbf{C} \times \mathbf{A}$?

   A. $(96.0 \text{ m}^2) \sin 25.0^\circ \mathbf{k}$
   B. $(96.0 \text{ m}^2) \cos 25.0^\circ \mathbf{k}$
   C. $-(96.0 \text{ m}^2) \sin 25.0^\circ \mathbf{k}$
   D. $-(96.0 \text{ m}^2) \cos 25.0^\circ \mathbf{k}$
   E. none of these

2. An object is moving along the $x$-axis. At a certain instant it is speeding up, and the rate at which it is speeding up is increasing. What can you conclude about the $x$-acceleration $a_x$ of the object at this instant?

   A. $a_x$ is positive and increasing
   B. $a_x$ is negative and decreasing (becoming more negative)
   C. $a_x$ is negative and increasing (becoming less negative)
   D. either answer A. or answer B. is possible
   E. either answer A. or answer C. is possible

3. The density of a material is equal to its mass divided by its volume. What is the density in kg/m$^3$ of a rock of mass 1.80 kg and volume $6.0 \times 10^{-4} \text{ m}^3$?

   A. $3 \times 10^1 \text{ kg/m}^3$
   B. $3.0 \times 10^3 \text{ kg/m}^3$
   C. $3.00 \times 10^3 \text{ kg/m}^3$
   D. $3.000 \times 10^3 \text{ kg/m}^3$
   E. Any of these — all of these answers are mathematically equivalent.

4. Which of the following statements is correct for any two vectors $\mathbf{A}$ and $\mathbf{B}$?

   A. The magnitude of $\mathbf{A} + \mathbf{B}$ is greater than or equal to $|\mathbf{A} - \mathbf{B}|$.
   B. The magnitude of $\mathbf{A} + \mathbf{B}$ is greater than or equal to the magnitude of $\mathbf{A} - \mathbf{B}$.
   C. The magnitude of $\mathbf{A} + \mathbf{B}$ is equal to $\sqrt{|\mathbf{A}|^2 + |\mathbf{B}|^2}$.
   D. More than one of the above statements is correct.
   E. None of the above statements is correct.

(CONTINUED ON NEXT PAGE)
MULTIPLE-CHOICE QUESTIONS (continued)

5. The position of an object moving along the $x$-axis is

$$x = (2.0 \text{ m/s}^2) t^2 - (6.0 \text{ m/s}^3) t^3 + (3.0 \text{ m/s}^4) t^4$$

What is the particle doing at $t = 1.0 \text{ s}$?

A. It is moving and speeding up
B. It is moving and slowing down
C. It is moving, but its velocity is not changing at this instant
D. It is momentarily at rest
E. Not enough information given to decide
Problem 1. (This problem is worth 40 points)
A sports car travels in the positive x-direction at a constant speed $v_{car}$. At $t = 0$ the sports car drives past a stop sign without stopping, and a policewoman on a motorcycle, which is initially at rest next to the stop sign, begins to move to catch up with the sports car. The policewoman speeds up at a constant rate until $t = T$, when her speed is $(3/2)v_{car}$. She then slows down at a constant rate until $t = 2T$, at which time she is alongside the sports car and traveling at the same speed $v_{car}$ as the sports car.

(a) On the axes below, sketch position–time ($x$–$t$) graphs showing the motion of the sports car and the policewoman. Draw the curves for both the sports car and the policewoman on the same set of axes, and label which curve is which. Be as accurate as possible — accuracy counts!

(b) On the axes below, sketch velocity–time ($v_x$–$t$) graphs showing the motion of the sports car and the policewoman. Draw the curves for both the sports car and the policewoman on the same set of axes, and label which curve is which. Be as accurate as possible — accuracy counts!

(CONTINUED ON NEXT PAGE)
Problem 1 (continued)

(c) Find the distance that the policewoman travels from $t = 0$ to $t = T$. For full credit, show your work, draw a box around your answers, and express your answer in terms of $v_{cu}$ and $T$.

(d) Find the distance that the policewoman travels from $t = T$ to $t = 2T$. For full credit, show your work, draw a box around your answers, and express your answer in terms of $v_{cu}$ and $T$. 
Problem 2 (This problem is worth 40 points)

A projectile is launched from the edge of the roof of a building as shown. The projectile leaves the roof moving at speed $v_0$ at a 45° angle above the horizontal. The instant before the projectile hits the ground, it is moving at an angle of 53° below the horizontal. Air resistance can be neglected.

Potentially useful information:

\[
\begin{align*}
\sin 45° & = \frac{1}{\sqrt{2}} & \cos 45° & = \frac{1}{\sqrt{2}} & \tan 45° & = 1 \\
\sin 53° & = \frac{4}{5} & \cos 53° & = \frac{3}{5} & \tan 53° & = \frac{4}{3}
\end{align*}
\]

(a) How much time elapses from when the projectile is launched to when it hits the ground? For full credit, show your work, simplify your answer, draw a box around your answer, and express your answer in terms of $v_0$ and $g$. Do not insert a numerical value of $g$ — if you do, you will receive zero points for this part.

(b) What distance to the right of the building does the projectile hit the ground? For full credit, show your work, simplify your answer, draw a box around your answer, and express your answer in terms of $v_0$ and $g$. Do not insert a numerical value of $g$ — if you do, you will receive zero points for this part.

(CONTINUED ON NEXT PAGE)
Problem 2 (continued)

(c) What is the height of the building? For full credit, show your work, simplify your answer, draw a box around your answer, and express your answer in terms of $v_0$ and $g$. Do not insert a numerical value of $g$ — if you do, you will receive zero points for this part.

(d) What is the speed of the projectile just before it hits the ground? For full credit, show your work, simplify your answer, draw a box around your answer, and express your answer in terms of $v_0$ and $g$. Do not insert a numerical value of $g$ — if you do, you will receive zero points for this part.

END OF THE EXAM
1. Explain Newton's First Law of Motion in your own words.

!  

Yakka food MOG. GRUG PABBWUP ZINZ WOTROOM GAZORK. CHUMBLE SPUZZ.

I LOVE LOOPHOLE.