Your name sticker with exam code. SIGN HERE:

1. The exam will last from 9:40 - 11:00 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labeled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit RUID Number.
4. Enter 123 under COURSE, and your section number (see label above) under SEC.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator, and one 8.5 x 11 inch sheet (both sides) with formulas and notes.
7. There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, hand in the answer sheet and the cover page. Retain this question paper for future reference and study.
8. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.
10. If needed, the acceleration due to gravity on earth may be taken as $g = 10 \text{ m/s}^2$. 

1
1. A ball is thrown vertically upward with an initial speed of 20 m/s. Two seconds later, a stone is thrown vertically upward (from the same initial height as the ball) with an initial speed of 24 m/s. At what height above the release point will the ball and stone collide? (Take \( g = 10 \text{ m/s}^2 \))

\[
y = v_o t - \frac{1}{2} g t^2 \quad \text{collision occurs when} \quad y_1 = y_2
\]

\[
20 t - 5 t^2 = 24 (t - 2) - 5 (t - 2)^2 \implies t = \frac{68}{24} = 2.83 \text{ s}
\]

\( 31 \text{ m} \)  
\( 17 \text{ m} \)  
\( 18 \text{ m} \)  
\( 27 \text{ m} \)  
\( 21 \text{ m} \)  

\[
y_1 = 20 (x - 2.83) - 5 (x - 2.83)^2 = 16.6 \quad \text{(17 m)}
\]

2. Given that \( \mathbf{A} + 2\mathbf{B} = x_1 \hat{i} + y_1 \hat{j} \) and \( 2\mathbf{A} - \mathbf{B} = x_2 \hat{i} + y_2 \hat{j} \), what is \( \mathbf{A} \)?

\[\begin{align*}
a) \quad \mathbf{A} &= \frac{1}{5} (x_1 + 4x_2) \hat{i} + \frac{1}{5} (y_1 + 2y_2) \hat{j} \\
b) \quad \mathbf{A} &= \frac{1}{5} (x_1 + 2x_2) \hat{i} + \frac{1}{5} (y_1 + 2y_2) \hat{j} \\
c) \quad \mathbf{A} &= \frac{1}{5} (x_1 + 4x_2) \hat{i} + \frac{1}{5} (y_1 + 4y_2) \hat{j} \\
d) \quad \mathbf{A} &= \frac{1}{5} (x_1 + 4x_2) \hat{i} + \frac{1}{5} (y_1 - 4y_2) \hat{j} \\
e) \quad \mathbf{A} &= \frac{1}{5} (x_1 - 2x_2) \hat{i} + \frac{1}{5} (y_1 - 2y_2) \hat{j}
\end{align*}\]

3. Scientists have determined that the critical mass of neptunium-237 is about 60 kg. The critical mass of a fissionable material is the minimum amount that must be brought together to start a nuclear chain reaction. The element has a density of 19.5 g/cm³. The radius of a sphere of this material that has a critical mass is

\[
M = \frac{4}{3} \pi R^3 \rho \quad \Rightarrow \quad R = \left( \frac{M}{\frac{4}{3} \pi \rho} \right)^{1/3}
\]

\[\begin{align*}
a) \quad 0.9 \text{ m} \\
b) \quad 9.0 \text{ mm} \\
c) \quad 9.0 \text{ m} \\
d) \quad 9.0 \text{ cm} \\
e) \quad 0.9 \text{ cm}
\end{align*}\]

4. You usually drive between Piscataway, NJ and Brooklyn, NY at an average speed of 60 km/hr and it takes one hour. On a Friday afternoon heavy traffic slows you down, and you drive the same distance at an average speed of only 45 km/hr. How much longer than usual does the trip take?

\[\begin{align*}
a) \quad 25 \text{ mins} \\
b) \quad 20 \text{ mins} \\
c) \quad 80 \text{ mins} \\
d) \quad 10 \text{ mins} \\
e) \quad 15 \text{ mins}
\end{align*}\]

\[
x = \frac{60}{45} = \frac{12}{9} = 1\frac{1}{3} \text{ hrs.}
\]

\boxed{20 \text{ mins more}}
5. If \( \mathbf{A} = 30\mathbf{i} + 11\mathbf{j} \) and \( \mathbf{B} \) (magnitude = 25) is as shown, what is the angle (measured CCW with respect to the positive x-axis) of the sum of these two vectors?

\[
\mathbf{A} = 30\mathbf{i} + 11\mathbf{j}
\]
\[
\mathbf{B} = -25 \sin 40\mathbf{i} + 25 \cos 40\mathbf{j}
\]

\[
\theta = \tan^{-1} \left( \frac{30}{14} \right) = 64.98^\circ \approx 65^\circ
\]

6. A particle starts from the origin at \( t = 0 \) with a velocity of \((12\mathbf{i} + 16\mathbf{j})\) m/s and moves in the xy plane with a constant acceleration of \((-2\mathbf{i} - 4\mathbf{j})\) m/s\(^2\). What is the distance of the particle from the origin at \( t = 2 \) s?

\[
u = 12\mathbf{i} + 16\mathbf{j}
\]
\[
a = (-2\mathbf{i} - 4\mathbf{j})
\]

\[
r = 0 + vt + \frac{1}{2}at^2
\]
\[
n = (12\mathbf{i} + 16\mathbf{j}) × 2
\]
\[
r = \frac{1}{2}(-2\mathbf{i} - 4\mathbf{j}) × 4
\]

a) 18 m
b) 31 m
c) 11 m
d) 45 m
e) 40 m

7. Which of the following products of ratios gives the conversion factor to convert miles per hour \( (\text{mi/h}) \) to meters per second \( (\text{m/s}) \)? (Note that \( f = \) foot)

\[
a) \frac{5280 \text{f}}{\text{mi}} \times \frac{12\text{in}}{\text{f}} \times \frac{2.54\text{cm}}{\text{in}} \times \frac{1\text{m}}{100\text{cm}} \times \frac{1\text{h}}{3600\text{s}}
\]
\[
b) \frac{5280 \text{f}}{\text{mi}} \times \frac{1\text{f}}{1\text{in}} \times \frac{2.54\text{cm}}{1\text{in}} \times \frac{1\text{m}}{100\text{cm}} \times \frac{1\text{h}}{3600\text{s}}
\]
\[
c) \frac{5280 \text{f}}{\text{mi}} \times \frac{1\text{f}}{1\text{in}} \times \frac{2.54\text{cm}}{1\text{in}} \times \frac{1\text{m}}{100\text{cm}} \times \frac{1\text{h}}{3600\text{s}}
\]
\[
d) \frac{5280 \text{f}}{\text{mi}} \times \frac{1\text{f}}{1\text{in}} \times \frac{2.54\text{cm}}{1\text{in}} \times \frac{1\text{m}}{100\text{cm}} \times \frac{1\text{h}}{3600\text{s}}
\]
\[
e) \frac{5280 \text{f}}{\text{mi}} \times \frac{1\text{f}}{1\text{in}} \times \frac{2.54\text{cm}}{1\text{in}} \times \frac{1\text{m}}{100\text{cm}} \times \frac{1\text{h}}{3600\text{s}}
\]
8. Force and acceleration are related by $F=ma$. Pressure, force and area are related by $p=F/A$. In the equation $F=kpx^2/v^2$, where $x$ is position and $v$ is velocity, what are the units of $k$?

a) $(T/L)^2$
b) none of the other answers
c) $L/T$
d) $(LT)^2$
e) $(L/T)^2$

9. An automobile manufacturer claims that its product will, starting from rest, travel 0.40 km in 9.0 s. What is the magnitude of the constant acceleration required to do this?

- $a = \frac{1}{2}at^2$
- $\alpha = 2x = \frac{2(400)}{81}$
- $a = 9.9 \text{ m/s}^2$

10. Assuming 365 days in a year, the number of seconds in a decade (10 years) is:

- $3.15 \times 10^7$
- $10 \text{ years} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 10 \times (365) \times (24) \times (3600) = 3.15 \times 10^8$

11. If $\vec{A} = 12\hat{i} - 16\hat{j}$ and $\vec{B} = -24\hat{i} + 10\hat{j}$, what is the magnitude of the vector $\vec{C} = 2\vec{A} - \vec{B}$?

- $|\vec{C}| = \sqrt{(2\times12)^2 + (2\times(-16) - (-24))^2} = 3.15 \times 10^8$

12. An object is dropped from rest at $t = 0$. Neglecting air resistance, how far does it drop between $t = 4s$ and $t = 5s$? Take $g = 10 \text{ m/s}^2$.

- $x(\text{t=4}) = 80$
- $x(\text{t=5}) - x(\text{t=4}) = 90$
- $x(\text{t=5}) = 125$
13. Two children start at one end of a street, the origin, run to the other end, then head back. On the way back Joan is ahead of Mike. Which statement is correct about the distances run and the displacements from the origin?

a) Joan has run a greater distance, but her displacement is less than Mike’s.
b) Mike has run a shorter distance, and his displacement is less than Joan’s.
c) Joan has run a greater distance and her displacement is greater than Mike’s.
d) Mike has run a greater distance and his displacement is greater than Joan’s.
e) Mike has run a greater distance, but his displacement is less than Joan’s.

14. One U.S. fluid gallon contains a volume of 231 cubic inches. How many liters of gasoline would you have to buy to fill a 14 gallon tank? (Note: 1L = 10^3 cm^3, 1 inch = 2.54 cm.)

\[ 14 \text{ gallons} = \frac{14 \text{ gal}}{1 \text{ gal}} \times \frac{231 \text{ in}^3}{1 \text{ gal}} \times \frac{1 \text{ gallon}}{1 \text{ in}^3} \times \frac{1 \text{ cm}^3}{(2.54 \text{ cm})^3} \]

15. A bicycle travels 308.5 m in a straight line in 40.3 s. The correct way to state the magnitude of its average velocity is:

a) 7.66 m/s
b) 7.7 m/s
c) 7.650868 m/s
d) 7.6 m/s
e) 7.655 m/s