You have 48 minutes for this midterm exam.

The exam is in your recitation room at the usual time.

Write your name and that of your recitation instructor on every sheet.

This exam is closed book, closed notes. No materials allowed.

You may use a calculator, but you must clear the memory. No cell phones or PDAs may be used as calculators.

We provide an equation sheet at the end. You cannot use your own.

All 10 multiple-choice problems are worth 5 points each, for a total of 50 points. You MUST put the correct letter in the space provided to obtain credit. If your writing is ambiguous, it will be marked as incorrect. No partial credit is given for multiple-choice problems.

The two show-work problems are worth 25 points each, with each sub-part worth 5 points. On the show-work problems, you are REQUIRED to show your work to get credit. We will grade it with partial credit, so the more of what you know that you write down, the better.
Equations and Constants

- **Quadratic Equation**: The solutions of \( ax^2 + bx + c = 0 \) are \( x = \frac{(-b \pm \sqrt{b^2 - 4ac})}{2a} \).

- **Average Velocity and Acceleration**:

\[
\vec{v}_{avg} = \frac{\vec{r} - \vec{r}_0}{t - t_0}, \\
\vec{a}_{avg} = \frac{\vec{v} - \vec{v}_0}{t - t_0}.
\]

- **Basic Kinematics**: For the motion in the \( x \)-direction, use

\[
\Delta x = v_{0x}t + \frac{1}{2}a_xt^2, \\
v_x = v_{0x} + a_xt, \\
v_x^2 = v_{x0}^2 + 2a_x\Delta x.
\]

Note that the displacement \( \Delta x = x_{final} - x_{initial} \); the book uses the notation \( x \) for \( \Delta x \).

For motion in the \( y \)-direction, use the same equations, but with \( y \) instead of \( x \) everywhere.

- **Relative Velocity**:

\[
\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}; \quad \vec{v}_{BA} = -\vec{v}_{AB};
\]

and separate into \( x \)- and \( y \)-components as needed.

- **Newton’s Second Law**: \( \vec{F}_{net} = \sum \vec{F} = m\vec{a} \), which separates into components as

\[
\sum F_x = ma_x, \\
\sum F_y = ma_y.
\]

- **Friction**: For static friction, \( f_s \leq f_{s maximum} = \mu_s F_N \); for kinetic friction, \( f_k = \mu_k F_N \).

- **Gravity**: \( F_G = \frac{Gm_1m_2}{r^2} \), where \( G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \). Also, \( g = 9.80 \text{ m/s}^2 \).

- **Constants**:

  - radius of Earth: \( R_E = 6.37 \times 10^6 \text{ m} \)
  - mass of Earth: \( M_E = 5.98 \times 10^{24} \text{ kg} \)