Answer all questions, beginning each new question in the space provided. Show all work. Show all formulas used for each problem prior to substitution of numbers. Label diagrams and include appropriate units for your answers. Write your name and section number at the top of each page in the space provided and write the name of your section instructor in the place provided in the cover sheet. You may use an alphanumeric calculator (one which exhibits physical formulas) during the exam as long as you do not program any formulas into memory. By using an alphanumeric calculator you agree to allow us to check its memory during the exam. Simple scientific calculators are always appropriate!

**A Formula Sheet Is Attached To The Back Of This Examination**

For your convenience you may carefully remove it from the Exam. Please take it with you at the end of the exam or throw it in a waste basket.

**Be Prepared to Show your Student ID Card**

**Score on each problem:**

I. (25) ___

II. (25) ___

III. (25) ___

IV. (25) ___

**Total Score (out of 100 pts) ___**
Part I. (5 points each) Put a circle around the letter that you think is the best answer.

I-1  A 1000-kg car is driving toward the north along a straight horizontal road at a speed of 20.0 m/s. The driver applies the brakes and the car comes to a rest uniformly in a distance of 200 m. What are the magnitude and direction of the net force applied to the car to bring it to rest?

A) 1.00 N north
B) $10.0 \times 10^3$ N south
C) $1.00 \times 10^3$ N south
D) 1.00 N south
E) 100 N south

I-2  A 60.0-kg person rides in elevator while standing on a scale. The elevator is traveling downward but slowing down at a rate of 2.00 m/s$^2$. The reading on the scale is closest to

A) 589 N.
B) 708 N.
C) 469 N.
D) 120 N.
E) 349 N.

I-3  On a horizontal frictionless floor, a worker of weight 900 N pushes horizontally with a force of 200 N on a box weighing 1800 N. As a result of this push, which statement could be true?

A) The box will not move because the push is less than its weight.
B) The worker and box will both have an acceleration of 1.09 m/s$^2$, but in opposite directions.
C) The worker and box will both have an acceleration of 2.18 m/s$^2$, but in opposite directions.
D) The worker will accelerate at 1.09 m/s$^2$ and the box will accelerate at 2.18 m/s$^2$, but in opposite directions.
E) The worker will accelerate at 2.18 m/s$^2$ and the box will accelerate at 1.09 m/s$^2$, but in opposite directions.
I-4 A car enters a 300-m radius horizontal curve on a rainy day when the coefficient of static friction between its tires and the road is 0.600. What is the maximum speed at which the car can travel around this curve without sliding?

A) 29.6 m/s
B) 33.1 m/s
C) 24.8 m/s
D) 42.0 m/s
E) 37.9 m/s

I-5 A new roller coaster contains a loop-the-loop in which the car and rider are completely upside down. If the radius of the loop is 13.2 m, with what minimum speed must the car traverse the loop so that the rider does not fall out while upside down at the top? Assume the rider is not strapped to the car.

A) 11.4 m/s
B) 12.5 m/s
C) 10.1 m/s
D) 14.9 m/s
Part II (5 points each part – total of 25 points)

Two masses, \( M_A \) (4 kg) and \( M_B \) (6 kg), are connected by a massless string and move on a horizontal surface. A horizontal pulling force, \( F \), is applied to \( M_B \). The coefficient of kinetic friction is \( \mu_k = 0.25 \) between \( M_A \) and the surface, but \( \mu_k = 0 \) between \( M_B \) and the surface.

A) Draw and label the physical situation.

B) Draw and label the appropriate free-body diagrams.

C) If the acceleration of the masses is \( 2.5 \text{ m/s}^2 \), determine the tension in the string.

D) Determine the net force acting on \( M_B \).

E) Determine the value of the pulling force, \( F \).
Part III (5 points each part – total of 25 points)

Three blocks, A, B, and C are in contact with each other and lie on a frictionless horizontal table. A horizontal force $F$ is applied block A. The blocks are lined up in a row with masses $M_A$, $M_B$, $M_C$.

A) Draw a free-body diagram for each block.

B) Identify the action-reaction force pairs.

C) Determine the acceleration of the blocks in terms of the masses and the applied force.

D) Determine the net force on each block in terms of forces drawn in part A).

E) If each block has a mass of 10 kg and $F$ equals 150 N determine the force of $M_A$ on $M_B$. 
Part IV (5 points each part – total of 25 points)

A) The pulley and string are massless and $M_B$ moves downward. Draw and label the free-body diagram for the two masses.

B) Using Newton's Second Law, write down the three equations for the setup.

C) Determine the expression for the acceleration in terms of the parameters given.

D) Determine the acceleration if the angle is 90 degrees.

E) Determine the acceleration if the angle is 0 degrees.
Graphical Analysis

\[ \bar{v}_{\text{avg}} = \frac{\Delta \bar{r}}{\Delta t} \] (slope of position versus time) \[ \Delta \bar{r} = \bar{r}_f - \bar{r}_i \]

\[ \Delta t = t_f - t_i \]

\[ \bar{a}_{\text{avg}} = \frac{\Delta \bar{v}}{\Delta t} \] (slope of velocity versus time)

\[ \bar{v}_{\text{inst}} = \frac{d\bar{r}}{dt} \] (slope of position versus time at a specific time)

\[ \bar{a}_{\text{inst}} = \frac{dv}{dt} = \frac{d^2 \bar{r}}{dt^2} \] (slope of velocity versus time at a specific time)

\[ S_f = S_i + \text{area under velocity versus time for } \Delta t = t_f - t_i \]

\[ V_{fs} = V_{is} + \text{area under acceleration versus time for } \Delta t = t_f - t_i \]

Analytical Analysis (for constant linear acceleration)

\[ S_f = S_i + v_{is} \Delta t + \frac{1}{2} a_s (\Delta t)^2 \]

\[ v_{fs} = v_{is} + a_s \Delta t \]

\[ v_{fs}^2 = v_{is}^2 + 2 a_s \Delta S \]
Graphical Analysis

$$\omega_{avg} = \frac{\Delta \theta}{\Delta t}$$  (slope of angular position versus time)

$$\alpha_{avg} = \frac{\Delta \omega}{\Delta t}$$  (slope of angular velocity versus time)

$$\omega_{inst} = \frac{d\theta}{dt}$$  (slope of angular position versus time at a specific time)

$$\alpha_{inst} = \frac{d\omega}{dt} = \frac{d^2 \theta}{dt^2}$$  (slope of angular velocity versus time at a specific time)

$$\Theta_f = \Theta_i + \text{area under angular velocity versus time for } \Delta t = t_f - t_i$$

$$\omega_{fs} = \omega_{is} + \text{area under angular acceleration versus time for } \Delta t = t_f - t_i$$

Analytical Analysis  (for constant angular acceleration)

$$\theta_f = \theta_i + \omega_i \Delta t + \frac{1}{2} \alpha (\Delta t)^2$$

$$\omega_f = \omega_i + \alpha \Delta t$$

$$\omega_f^2 = \omega_i^2 + 2\alpha \Delta \theta$$

$$s = r \theta$$  \hspace{1cm} $$v = r \omega$$

$$a_i = r \alpha$$  \hspace{1cm} $$a_r = r \omega^2 = \frac{v^2}{r}$$