Name ________________________________________, _________________________  
Last Name    First Name

Student Identification Number:

- Write your name at the top of each page in the space provided.
- 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.
- 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 OK!

Score on each part

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Total Score (out of 150 pts)  

Total Score (scaled up to 200 pts)
Problem 1: (15 points) - 3 pts each -- No partial credit on this problem only. 
Put a circle around the letter that you think is the best answer.

I-1  Angular momentum cannot be conserved if  
A)  the angular acceleration changes.  
B)  the angular velocity changes.  
C)  there is a net force on the system.  
D)  the moment of inertia changes.  
E)  the net torque is not zero.

I-2  A person sits on a freely spinning lab stool (no friction). When this person extends her arms,  
A)  her moment of inertia decreases and her angular velocity increases.  
B)  her moment of inertia decreases and her angular velocity decreases.  
C)  her moment of inertia increases and her angular velocity increases.  
D)  her moment of inertia increases and her angular velocity decreases.  
E)  her moment of inertia increases and her angular velocity remains the same.

I-3  Two children are riding on a merry-go-round. Child A is at a greater distance from the axis of rotation than child B. Which child has the larger angular speed?  
A)  Child A  
B)  Child B  
C)  They have the same zero angular speed.  
D)  They have the same non-zero angular speed.  
E)  There is not enough information given to answer the question.
I-4  A solid disk and a hoop of the same mass and radius are released at the same time at the top of an inclined plane and roll without slipping. Which object reaches the bottom of the incline first?

A)  The hoop

B)  The disk

C)  Both reach the bottom at the same time.

D)  It depends on the angle of inclination.

E)  It depends on the length of the inclined surface.

I-5  Planet Z-34 has a mass equal to one-third that of Earth and a radius equal to one-third that of Earth. With $g$ representing, as usual, the acceleration due to gravity on the surface of Earth, the acceleration due to gravity on the surface of Z-34 is

A)  $g/3$.

B)  $3g$.

C)  $6g$.

D)  $g/9$.

E)  $9g$. 
Problem 2 – short problems (5 points each)

2-1- A 60.0-kg person rides in elevator while standing on a scale. The elevator has an acceleration 2.00 m/s² upward. What is the reading on the scale?

2-2- A ball is tied to the end of a cable of negligible mass. The ball is spun in a circle with a radius 2.00 m making 0.700 revolutions per second. What is the centripetal acceleration of the ball?

2-3 – A force, \( \vec{F} \) (in N) is applied to an object at position, \( \vec{r} \) (in m). What is the torque about the origin? \[ \vec{F} = 4.0 \hat{i} - 3.0 \hat{j} \quad \text{and} \quad \vec{r} = 2.0 \hat{i} + 3.0 \hat{j} \]

2-4 – A 50-gram mass when attached to a spring has oscillations as shown.

A) Determine the amplitude.

B) Determine the frequency.

C) Determine the period.

D) Determine the angular frequency.

E) Determine the spring constant.
Problem 3: (25 points)

A player applies a constant force of 270 N for 0.050 s on a ball (mass = 0.45 kg) resulting in the ball being projected an angle of 37 degrees above the ground.

A) Determine the velocity of the ball after the kick.

B) Determine the maximum height ($y_{\text{max}}$) of the ball.

C) Determine the total time that the ball is in the air.

D) Determine the components of the velocity plus its magnitude and direction at one third of the total time.

E) Determine the horizontal distance traveled by the ball when it returns to the ground.
Problem 4: (25 points)

Two masses $m_A$ and $m_B$ are on inclines and are connected together by a massless string.

**m_B is greater than m_A ; There is no friction involved in the motion and the pulley is massless.**

A) Draw and label clearly the free-body diagram for each block.

B) Using Newton’s Second Law, write down the equations that will allow the determination of the motion of the blocks.

C) Solve the equations in order to determine an expression for the acceleration of the blocks in terms of $m_A$, $m_B$, $\theta_A$, $\theta_B$, and $g$ – show all steps clearly.
D) If $m_A = 2.0 \text{ kg}$, $m_B = 5.0 \text{ kg}$, $\theta_A = 51^\circ$ and $\theta_B = 21^\circ$ determine for the acceleration of the blocks.

E) Determine the tension in the string.

The masses move a distance of 2.0 m.

F) Determine the work done by each of the forces acting on mass A.

G) Determine the work done by each of the forces acting on mass B.
Problem 5: (15 points)

In an experiment, a projectile of mass $m$ collides with a ballistic pendulum of mass $M$. It gets embedded in the pendulum, which rises to a maximum height of $h_1$.

A) Find an expression for the final velocity, $v_{f1}$ of the system. – show all steps clearly.

B) Find the initial velocity, $v_{i1}$ of the projectile – show all steps clearly.

C) A second projectile of the same mass, but with initial velocity $v_{i2}$ causes the pendulum to rise to a maximum height of $h_2$.

Determine the ratio $v_{i2} / v_{i1}$
Problem 6: (25 points)

The figure above shows two masses connected by a massless cord that passes over a pulley of radius $R$ and moment of inertia $I$.

The horizontal surface is frictionless.

A) Draw the free-body diagram for the two masses and the pulley.

B) Apply Newton’s Second Law to write down the equations for the setup.

C) Find an expression for the linear acceleration of the masses (in terms of $m_A$, $m_B$, $I$, $R$, and $g$) – write all the steps clearly.
Problem 7: (10 points)

A wheel is rotating around a vertical axis through its center at a frequency of 1.5 rev/s. The wheel can be considered a uniform disk of mass 5.0 kg and diameter 0.40 m. A clay shaped as a flat disk of mass 3.6-kg and radius 8.0-cm falls on the rotating wheel.

A) What is the angular velocity of the wheel after the clay sticks to it?

B) Calculate the final rotational kinetic energy
Problem 8: (15 points)

\[ G = 6.67 \times 10^{-11} \text{Nm}^2/\text{kg}^2 \quad M_E = 5.98 \times 10^{24} \text{kg} \quad R_E = 6.37 \times 10^6 \text{ m} \]

Planet X has a mass of 3 times that of Earth and the acceleration due to gravity at the surface of the Planet X is 1/5 (one fifth) that of Earth’s.

A) Determine the radius of Planet X.

B) Determine the escape velocity (from its surface) of Planet X.

C) A satellite (of mass = 10^{-15} \text{ kg}) is orbiting around the Planet X, 150 km above the planet’s surface in a circular orbit. Determine the orbital velocity of the satellite.