EXAM 2

Please print your name and section number (or TA's name) clearly on the first page. Show all your work in the space immediately below each problem. Your final answer must be placed in the boxes, when provided. Problems will be graded on reasoning and intermediate steps as well as on the final answer. Be sure to include units wherever necessary, the direction of vectors, and the correct number of significant figures. Check your answers to see that they have the correct dimensions (units) and are the right order of magnitude. You are allowed 1 side of 1 sheet of notes (8.5” x 11”, 1 side), a calculator, and the constants in this exam booklet. Each part is worth 20 points. Try to be neat! The exam lasts 1.25 hours.

Constants and Conversion Factors:

Acceleration due to gravity at Earth’s surface: $g = 9.81 \text{ m/s}^2$

1.0 km = 0.62 miles

1 hp = 746 W

moment of inertial, I, for a solid disk of mass M and radius R = $MR^2/2$

SCORE:

Problem 1: _________
Problem 2: _________
Problem 3: _________
Problem 4: _________
Problem 5: _________
TOTAL: _________

Please don't open the exam until you are instructed to start.
**Part 1**

A. Two boxes are sitting side by side on a frictionless surface. The box on the left has a mass of \( m \), and the box on the right has a mass of \( M \). If a force \( F \) pushes on box \( m \) from the left, what is the force exerted on box \( M \) by box \( m \)? (12 pts)

B. A piano mover raises a 100 kg piano at a constant rate using a frictionless pulley system, as shown below. With roughly what force is the mover pulling down on the rope? (8 pts)
Part 2
A. Future space stations will create an artificial gravity by rotating. Consider a cylindrical space station of 390 m diameter rotating about its axis. Astronauts walk on the inside surface of the space station. What rotation period will provide "normal" gravity? (8 pts)

B. If you walk up a hill, the work done by you is (3 pts)
   a. positive  b. negative  c. zero

C. If you walk up a hill, the work done on you by the force of gravity is (3 pts)
   a. positive  b. negative  c. zero

D. If you walk up a hill, the part of the work you do against gravity is (3 pts)
   a. lost  
   b. converted to kinetic energy  
   c. stored in your gravitational potential energy

E. If you walk up a hill and stop at the top, the part of the work that your muscles do above and beyond what you do against gravity is (3 pts)
   a. converted to heat, used to evaporate sweat, etc.  
   b. converted to kinetic energy  
   c. stored in your gravitational potential energy
Part 3
A. Two vehicles approach a right angle intersection and then collide. After the collision, they become entangled. If their mass ratios were 1:5 and their respective speeds as they approached were 16 m/s and 17 m/s, find the magnitude of the final velocity of the wreck. (15 pts)

B. A 5 kg ball collides head-on with a 10 kg ball, which is initially stationary. The collision is inelastic. Which statement is true? (5 pts)
   i) The magnitude of the change of velocity the 5 kg ball experiences is greater than that of the 10 kg ball.
   ii) The magnitude of the change of velocity the 5 kg ball experiences is less than that of the 10 kg ball.
   iii) The magnitude of the change of velocity the 5 kg ball experiences is equal to that of the 10 kg ball.
   iv) The magnitude of the change of the momentum of the 5 kg ball is equal to the magnitude of the change of momentum of the 10 kg ball.
   v) Two of the above statements are true.
Part 4

A. A spring-loaded dart gun is used to shoot a dart straight up into the air, and the dart reaches a maximum height of 24 meters. The same dart is shot up a second time from the same gun, but this time the spring is compressed only half as far (compared to the first shot). How far up does the dart go this time (neglect friction and assume the spring obeys Hooke's law)? (7 pts)

B. The plot below shows the potential energy of an electron, due to the force exerted on it by the nucleus of an atom, as a function of distance. For which point(s) is the force exerted on the electron zero? (6 pts)

C. A car needs to generate 75.0 hp in order to maintain a constant velocity of 27.3 m/s on a flat road. What is the magnitude of the total resistive force acting on the car (due to friction, air resistance, etc.)? (7 pts)
Part 5
A. A potter’s wheel (a solid, uniform disk) of mass 6.1 kg and radius 0.65 m spins about its central axis. A 2.1 kg lump of clay is dropped onto the wheel at a distance 0.41 m from the axis. Calculate the rotational inertia of the system. (10 pts)

B. A wheel accelerates from rest to 59 rad/s at a rate of 74 rad/s². Through what angle (in radians) did the wheel turn while accelerating? (10 pts)