

| Problem      | Points | Score |
|--------------|--------|-------|
| 1            | 8      |       |
| 2            | 15     |       |
| 3            | 15     |       |
| 4            | 12     |       |
| <b>Total</b> | 50     |       |

**Instructions:**

- Do all of your work in this booklet.
- Show all of your steps in problems for full credit.
- Be clear and neat in your work. Any illegible work, or scribbling in the margins, will not be graded.
- Place your answers in a box.
- If you need more space, you may use the back of the page and write **On back** in the problem space.

1. **Multiple Guess (8 pts)** Find the answer which best fits the question and write it in the space provided.

- The units of torque are \_\_\_\_\_  
 a) N/m; b) Nm/s c) Nm d) J; e) none of these.
- The tangential speed at a point on the rim of a hubcap on a uniformly rotating car wheel is \_\_\_\_\_  
 a) greater than at a point on the tire; b) the same as a point on the tire; c) greater than the translational velocity when there is no slipping; d) none of these.
- Stepping on the gas as one drives around a circular track increases the \_\_\_\_\_  
 a) radial acceleration b) tangential acceleration c) moment of inertia d) center of gravity of the car e) none of these.
- 0.004 radians is closest to \_\_\_\_\_ degrees.  
 a) .001 b) 0.22 c) 1.00 d) 4.0 e) 12.6
- Two objects are separated by a distance R. If one of the objects is replaced by another having half as much mass and the separation distance is halved, then the gravitational force is \_\_\_\_\_  
 a) twice as much; b) half as much; c) four times as much; d) a quarter as much; e) the same.
- A geosynchronous satellite \_\_\_\_\_  
 a) has a period of one month. b) has a period of one day. c) travels at the same speed as the moon. d) sends periodic flashes to the Earth's surface.
- When one stretches liquorice, the stress is given by \_\_\_\_\_  
 a) the change in length per original length; b) the applied force per unit area; c) the restoring force; d) none of these.
- If an object displaces an amount of liquid of greater weight than its own, the object will \_\_\_\_\_  
 a) float b) sink c) remain in equilibrium for any submerged position.

**Bonus:** There is a 0.010 m thick layer of ice on a circular lake of radius 500 m. Find the mass of the ice. (Density of Ice 920 kg/m<sup>3</sup>)

2. **Definitions/Principles (15 pts)**

a. Fill in the missing analogous quantities:

| Physical concept | Rotational | Translational |
|------------------|------------|---------------|
| Displacement     | _____      | x             |
| Inertia          | I          | _____         |
| Acceleration     | _____      | a             |
| Force            | _____      | F             |

b. Identify the source (i.e., force) of centripetal acceleration in the following:

- Model plane on guide wire rotating in a circle.
- Car turning corner at constant speed on a level road.
- Planet circling the Sun.

c. List the moments of Inertia for the following:

- Sphere of mass M and radius R \_\_\_\_\_
- Solid disk of mass M and radius R \_\_\_\_\_
- Hoop of mass M and radius R \_\_\_\_\_

d. For each of the above objects in part c, determine the order in which each will arrive at the bottom of an inclined plane when starting at the same height from rest: (Hint: Think about how the rotational K is affected by I.)

- First \_\_\_\_\_
- Second \_\_\_\_\_
- Third \_\_\_\_\_

e. What is the arc length subtended by an angle of 60° radians on a circle with a diameter of 12.0 cm?

**Constants**

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$        $M_E = 5.98 \times 10^{24} \text{ kg}$   
 $R_E = 6.38 \times 10^3 \text{ km}$        $1 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$

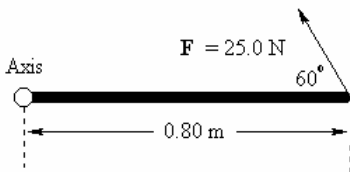
**3. Rotational Dynamics (15 pts)**

a. A wheel rotating at 20 rev/min slows and stops in 15 s.

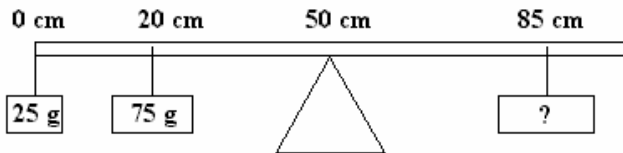
(i) Assuming uniform deceleration, through how many revolutions did it turn in this time?

(ii) If the wheel has a radius of 40 cm and rolls without slipping, how far did it roll in the 15 s?

b. In the figure below draw the line of action and moment arm. Determine the torque produced by the force on the rod.



c. Draw and label all of the forces on the figure. Determine the third mass that will put this system in static equilibrium.



d. A satellite circles moves in a circular orbit above the Earth at a distance of 1000 km. How fast is the satellite moving?

e. A skater has a moment of inertia of  $100 \text{ kg m}^2$  with arms outstretched and  $80 \text{ kg m}^2$  with arms tucked in. If the skater is rotating at 6 rad/s and then tucks in her arms, what is the new angular velocity?

**4. Miscellaneous. (12 pts)**

a. A uniform block of wood is 20.0 cm on a side. It floats in water so that its upper surface is 6.0 cm above the water surface. What is the buoyant force on the wood?

b. The deep end of a swimming pool has a depth of 3.00 m. The atmospheric pressure above the pool is one atmosphere. What is the pressure at the bottom of the pool in Pascals?

c. A 3500 kg statue is placed on top of a cylindrical concrete stand. ( $Y = 2.3 \times 10^{10} \text{ N/m}^2$ ). The stand has a cross-sectional area of  $7.3 \times 10^{-2} \text{ m}^2$  and a height of 1.8 m. By how much does the statue compress the stand?

d. Mars has a mass of  $6.46 \times 10^{23} \text{ kg}$  and a radius of  $3.39 \times 10^6 \text{ m}$ . How much would a 70 kg person weigh on Mars?

e. A motorist uses a hydraulic jack by applying a force of 7.0 N to the input piston. If the area of the output plunger is five times that of the piston, what is the output force?