Rotational Dynamics

1. A balance scale consisting of a weightless rod has a mass of 0.1 kg on the right side 0.2m from a pivot point.
   a. How far from the pivot point on the left must 0.4 Kg be placed so that balance is achieved ? Ans 0.05 m
   b. If the 0.4 Kg mass is suddenly removed, what is the instanteneous rotational acceleration of the rod? Ans 49 rad/sec
   c. what is the instantaneous tangential acceleration of the 0.1 Kg mass when the 0.4 Kg mass is removed ? Ans 9.8 m/sec

2. A large wheel of radius 0.4m and moment of inertia 1.2 Kgm^2, pivoted at the centre is free to rotate without friction. A rope is wound it and a 2 Kg weight is attached to the rope. When the weight has descended 1.5m from its starting point
   a. what is its downward velocity? Ans 2.5 m/sec
   b. What is the rotational velocity of wheel ? Ans 6.2 rad/sec

3. A bicycle wheel of mass 2 Kg and radius 0.32m is spinning freely on its axle at 2 rev sec^{-1}. When you place your hand against the tyre, the wheel decelerates uniformly and comes to a stop in 8 Sec. What was the torque of your hand against the wheel ? Ans -0.64 Nm

4. A grindstone with M.I. 240 Kgm^2 rotates with a speed of 1 rev sec^{-1}. A knife blade is pressed against it, and the wheel coasts to a stop with constant declaration in 12 Sec. What torque did the knife exert on the wheel? Ans 125.66 Nm

5. Two masses, m_1 =1 Kg and m_2 = 5 Kg are connected by a rigid rod of negligible weight. The system is pivoted about point O. The gravitational forces act in the negative direction
   a. Express the position vectors and the forces on the masses in terms of unit vectors and calculate the torque on the system. Ans $-180\hat{i}$ Nm
   b. What is the angular acceleration of the system at the instant. Ans -2.14i rad/sec

6. A uniform wooden board of mass 20 Kg resets on two supports as shown in figure. A 30 Kg steel block is placed to the light of support A. Ho0w far to the right of a can the steel the block be placed without tipping the board ? Ans 2m right from A

7. A children's merry go-round of radius 4m and mass 100 Kg has an 80 Kg man standing at the rim. The merry go-round coasts on a friction less bearing at 0.2 rev Sec^{-1}. The man walks inward 2m towards the centre. What is the new rotational speed of the merry go-round ? What is the source of this energy ? (The moment of inertia of a solid disk is $I=mr^2/2$) Ans 0.371 rev/sec

8. Suppose the body of an ice skater has a moment of inertia 4 Kgm^2 and her arms have a mass 5 Kg each with the centre of mass at 0.4 m from her body. She starts to turn at 0.5 rev/sec on the point of her skate with her arms out stretched. She then pulls her arms inward so that their centre of mass is at the axis of her body is zero. What is the speed of rotation ? Ans 0.7 rev/sec

Oscillatory motion

1. A given spring stretches 0.1m when a force of 20N pull on it. A 2 Kg block attached top it on a friction less surface pulled to the right 0.2m and released.
   a. What is the frequency of oscillation of the block ? Ans 1.6 Hz
   b. What is its velocity at the midpoint ? Ans 2 m/sec
   c. What is its acceleration at either end ? Ans 20.19 m/sec
   d. What are the velocity and acceleration when x=0.12 m on the block's first passing this point ? Ans 12.12 m/sec^2

2. A spring mass system consists of a 2 Kg mass block and spring constant 200N/m. The block is released from the position of x_1=0.2m.
   a. What is its velocity at x_2 =0.1m Ans 1.73 m/Sec
   b. What is the acceleration at this point ? Ans 10 m/Sec^2

3. An oscillating block of mass 250 gm takes 0.15 sec to move between the end points of the motion, which are 40 cm apart.
   a. What is the frequency of the motion ? Ans 6.67 rev/ sec
   b. What is the amplitude of the motion ? Ans 20 X 10^{-2} m
   c. What is the force constant of the spring ? Ans 439.08 Nm^{-1}

4. A spring of force constant 200 N/m is compressed 10 cm between two blocks of mass m_1=1.5 Kg and m_2=4.5 Kg. The spring is not connected to the block and the table is friction less. What are the velocities of the blocks after they are released and loss contact with the spring ? Assume that the spring falls straight down to the table. Ans 0.33 m/sec

5. A block is oscillating with amplitude of 20 cm. The spring constant is 150 N/m .
   a. What is the energy of the system ? Ans 3 J
   b. When the displacement is 5 cm, what are the kinetic energy of the block and the potential energy of spring ? Ans 2.81 J & 0.19 J