# INDIAN INSTITUTE OF TECHNOLOGY, BHUBANESWAR

**ASSIGNMENT NO.-03**

**Course: ME20001 DYNAMICS (Second year Autumn Semester 2011)**

**[Kinetics of Rigid Body in plane Motion:: (Newton's second law of Motion, Work and Energy Method, Momentum and Impulse Method) & Mechanical Vibration]**

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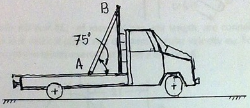
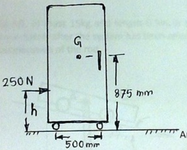
Q.1. A 2-m board is placed in a truck with one end on the floor and the other leaning against a vertical partition. Knowing that the coefficient of static friction is 0.03 between the board and the floor and zero between the board and the partition determine the maximum allowable deceleration of the truck, if the board is to remain in the position shown.




Ans: 7.97 m/s²

Q.2. An 35 kg cabinet is mounted on casters which allow it to move freely ($\mu = 0$) on the floor. If a 250-N force is applied as shown, determine (a) the acceleration of the cabinet, (b) the range of values of h for which the cabinet will not tip.

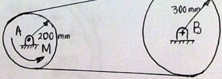
Solve previous problem assuming that the casters are are locked and slide along the rough floor ($\mu_k = 0.25$).




Ans. (a) 4.69 m/s², (b) $231 \leq h \leq 918$ mm.

Q.3. Two disks A & B, of mass $m_A = 2$ kg and $m_B = 4$ kg are connected by a belt as shown. Assuming on slipping the belt and the disks, determine the angular acceleration of each disk if a 2.70 N.m couple M is applied to disk A .

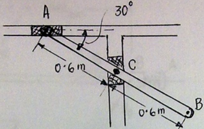
Solve previous problem assuming that the 2.70 N.m couple M is applied to disk B.




Ans: $\alpha_A = 15$ rad/s² (A.C.W.) $\alpha_B = 10$ rad/s² (A.C.W.)

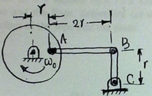
Q.4. The motion of the 4 kg uniform rod ACB is guided by two blocks of negligible mass which slide without friction in the slots shown. If the rod is released from rest in the position shown, determine immediately after release (a) the angular acceleration of the rod, (b) the reaction at A.

The motion of the 4 kg uniform rod ACB is guided by two blocks of negligible mass which slide without friction in the slots shown. A horizontal force P is applied to block A, causing the rod to start from rest with a counter clockwise angular acceleration of 12 rad/s². Determine (a) the required force P, (b) the corresponding reaction at A.



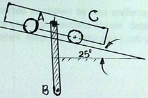

Ans: (a) 130.4 ←, (b) 64.2 N ↑

Q.5. Two rods AB and BC, of mass m' per unit length, are connected as shown to a disk which is made to rotate in a vertical plane at a constant angular velocity $\omega_0$. For the position shown, determine the components of the forces exerted at A and B on rod AB.



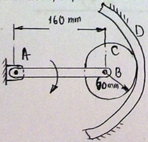

Ans: $A_x = 3m' r^2 \omega_0^2$ $A_y = m' gr$
$B_x = \frac{1}{2} m' r^2 \omega_0^2$ $B_y = m'gr$

Q.6. A uniform rod AB, of mass 15kg and length 0.9m, is attached to the 20 kg cart C. Neglecting friction, determine immediately after the system has been released from rest, (a) the acceleration of the cart, (b) the angular acceleration of the rod.



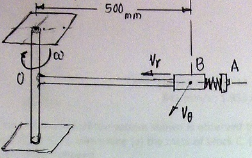

Ans. (a) 5.63 m/s², (25°), (b) 8.51 rad/s (c.w.)

Q.7. Gear C has a mass of 3.2 kg and a centrodial radius of gyration of 60 mm. the uniform bar AB has a mass of 2.4 kg, and gear D is stationary. If the system is released from rest in the position shown, determine the velocity of point B after bar AB has rotated through 90° ~~for both cases~~ as shown in figure below.



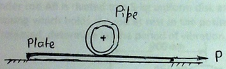

Ans: 1.543 m/s

Q.8. Collar B has mass of 3 kg and may slide freely on rod OA, which in turn may rotate freely in the horizontal plane. The assembly is rotating with an angular velocity $\omega$ = 1.8 rad/s when a spring located between A and B is released, projecting the collar along the rod with and initial relative speed $v_r$= 1.5 m/s. Knowing that the moment or inertia about O of the rod and spring is 0.35 kg. m², determine (a) the minimum distance between the collars and point O in the ensuring motion, (b) the corresponding angular velocity of the assembly.



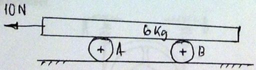

Ans: 100.2 mm, (b) 5.21 rad/s.

Q.9. A 160-mm- diameter pipe of mass 6 kg rests on a 1.5 mm plate. The pipe and plate are initially at rest when a force P of magnitude 25 N is applied for 0.75 s. Knowing that $\mu_s$ = 0.25 and $\mu_k$ = 0.25 between the plate and both the pipe and the floor, determine (a) whether the pipe slides with respect to the plate, (b) the resulting velocities of the pipe and the plate.



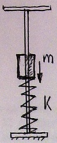

Ans: (a) pipe rolls without sliding
(b) pipe: 0.857 m/s
10.71 rad/s (A.C.W.)
Plate: 1.714 m/s

Q.10. The 6 kg carriage is supported as shown by two uniform disks, each having a mass of 4 kg and radius of 75 mm. Knowing that the carriage is initially at rest, determine the velocity of the carriage 2.5s after the 10-N force has been applied. Assume that the disks roll with sliding.



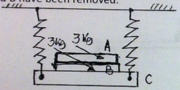

Ans: 2.78 m/s

Q.11. A 2.5kg collar rests on, but is not attached to, the spring shown. The collar is depressed 75 mm and released. If the ensuing motion is to be simple harmonic, determine (a) the largest permissible value of spring constant K, (b) the corresponding position, velocity and acceleration of the collar 0.12 s after it has been released.



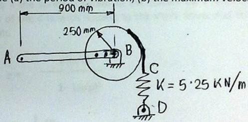

Ans. (a) 327 N/m (b) 14.78 mm below equilibrium position; 841 mm/s ; 1.933 m/s²

Q.12. The period of vibration of the system shown is observed to be 0.8 s. If block A is removed, the period is observed to be 0.7 s. Determine (a) the mass of block C, (b) the period of vibration when both blocks A and B have been removed.

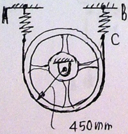



Ans. (a) 6.80 kg (b) 0.583 s.

Q.13. A 7-kg slender rod AB is riveted to a 5-kg uniform disk as shown. A belt is attached to the rim of the disk and to a spring which holds the rod at rest in the position shown. If end A of the rod is moved 18 mm down and released, determine (a) the period of vibration, (b) the maximum velocity of end A.

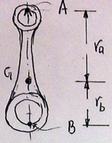



Q.14. A belt is placed around the rim of a 240-kg flywheel and attached as shown to two springs, each of constant k= 15 kN/m. If end C of the belt is pulled 40 mm down and released, the period of vibration of the flywheel is observed to be 0.5 s. knowing that the initial tension in the belt is sufficient to prevent slipping, determine (a) the maximum angular velocity of the flywheel, (b) the centroidal radius of gyration of the flywheel.



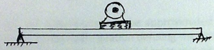

Ans. (a) 1.117 rad/s (b) 400 mm

Q.15. The period of small oscillation about A of a connecting rod is observed to be 1.03 s. Knowing that the distance $r_a$ is 160 mm, determine the centroidal radius of gyration of the connecting rod.




Ans; 128.8 mm.

Q.16. A 100-kg motor is supported by a light horizontal beam. The unbalance of the rotor is equivalent to a mass of 22 g located 180 mm from the axis of rotation. Knowing that the static deflection of the beam due to the mass of the motor is 5.5 mm, determine (a) the speed (in r/min) at which resonance will occur, (b) the amplitude of the steady-state vibration of the motor at a speed of 720 r/min. Assuming that the 100-kg motor at a speed of 720 r/min. Assume that the motor is supported by a rest of springs having a total spring constant of 45 kN/m.

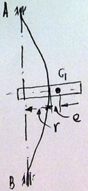


Ans; (a) 203 rpm, (b) 43.0 Mm.

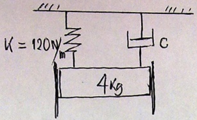
Q.17. A disk of mass m is attached to the midpoint of a vertical shaft AB, which revolves at a constant angular velocity ω. Denoting by k the spring constant of the system for a horizontal movement of the disk and by *e* the eccentricity of the disk with respect to the shaft, show that the deflection *r* of the shaft may be written in the form.

$$r = \frac{e(\omega/p)^2}{1-(\omega/p)^2}$$

Where $p = \sqrt{k/m}$.



Q. 18. The block shown is depressed 30 mm from its equilibrium position and released. Knowing that after 10 cycles the maximum displacement of the block is 18 mm, determine (a) the damping factor $c/c_c$, (b) the value of the coefficient of viscous damping.




Ans. (a) $8.13 \times 10^{-3}$, (b) 0.356 N.S./m

Q.19. A 25-kg motor is supported by four springs, each having a constant of 200 kN/m. The unbalance of the rotor is equivalent to mass of 30 g located vertically, determine the amplitude of the steady-state vibration of the motor at a speed of 1800 r/min, assuming (a) that no damping is present , (b) that the damping factor $c/c_c$ is equal to 0.125.

Ans. (a) 0.549, (b) 56.8 N

Q.20. The suspension of an automobile may be approximated by the simplified spring and dashpot system shown. (a) Write the differential equation defining the absolute motion of the mass m when the system moves at a speed v over a road of sinusoidal cross section as shown. (b) Derive an expression for the amplitude of the absolute motion m.

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