		Surname		Type
Group Number		Name		A
List Number		e-mail		
Student ID		Signature		

ATTENTION: Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

1. An object at rest begins to rotate with a constant angular acceleration. If this object rotates through an angle θ in the time t, through what angle did it rotate in the time $t/2$?

(a) $\theta/2$ (b) 2θ (c) 4θ (d) $\theta/4$ (e) θ

2. An object at rest begins to rotate with a constant angular acceleration. If this object has angular velocity ω at time t, what was its angular velocity at the time $t/2$?

(a) $\omega/2$ (b) 2ω (c) $\omega/8$ (d) 4ω (e) $\omega/4$

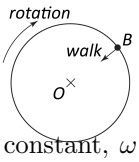
3. A force $\vec{F} = 4\hat{\imath} + 3\hat{\jmath}$ N acts on an object at a point located at the position $\vec{r} = 6\hat{k}$. What is the torque that this force applies about the origin?

(a) $24\hat{\imath} + 18\hat{\jmath}$ N.m (b) 0 (c) $-18\hat{\imath} + 24\hat{\jmath}$ N.m (d) $24\hat{\imath} - 18\hat{\jmath}$ N.m (e) $-18\hat{\imath} - 24\hat{\jmath}$ N.m

4. Disks A and B are identical and roll across a floor with equal speeds v. Disk A then rolls up an incline with angle α without slipping, reaching a maximum height h_A. Disk B moves up an incline that is identical (i.e. it has the same angle α) except that it is frictionless, reaching a maximum height h_B. What is the relationship between h_A and h_B?

(a) It depends on the value of v (b) $h_B > h_A$ (c) $h_B < h_A$ (d) It depends on the value of α (e) $h_B = h_A$

5. A beetle B sits on the rim of a small disk that rotates about its center O (see the picture). If the beetle starts walking toward the center of the disk (in the direction of the arrow), what happens to the total moment of inertia I, angular momentum L, and angular speed ω of the system "beetle + disk" (each quantity relative to the point O)?



(a) I decreases, L is constant, ω decreases (b) I increases, L is constant, ω decreases (c) I increases, L is constant, ω increases (d) I decreases, L is constant, ω increases (e) I, L, and ω are constant

6. A massive uniform ball is hung by a string from a fixed support (simple pendulum) on the earth and is in equilibrium position. Assume that the earth is perfect sphere in spite of its rotation about its own axis. Which of the following statements is/are then correct?

i) Independent of the latitude, the tip of the pendulum always points exactly the centre of gravity of the earth.

ii) The magnitude of the tension in the string depends on the latitude.

iii) The magnitude of the weight of the ball depends on the latitude.

(a) i, ii and iii (b) ii and iii (c) i and iii (d) i (e) ii

7. What is the relation between the total mechanical energy E and kinetic energy K of a satellite revolving in a circular orbit around the earth? Ignore the sky objects other than the earth and the rotation of the satellite about its own axis.

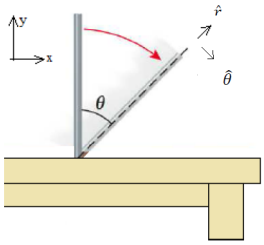
(a) $E = K/2$ (b) $E = -K$ (c) $E = K$ (d) $E = -2K$ (e) $E = 2K$

8. Your personal spacecraft is in a low-altitude circular orbit around the earth. Air resistance from the atmosphere on your spacecraft would lead your spacecraft to

(a) slow down and approach to the earth (b) speed up and recede from the earth (c) speed up and approach to the earth (d) slow down by preserving its altitude (e) slow down and recede from the earth

Questions 9-10

A uniform rod of mass M = 1 kg stands vertically on a horizontal table. It is released from rest to fall. Assume that acceleration due to gravity g=10 m/s^2 and coefficient of static friction between the table and the rod is 0.6. ($\sin 37^\circ = 0.6$, $\cos 37^\circ = 0.8$) ($I_{cm} = \frac{1}{12}MR^2$)



9. Calculate the normal force exerted by the table on the rod as it makes an angle $\theta = 37^o$ with respect to the vertical.

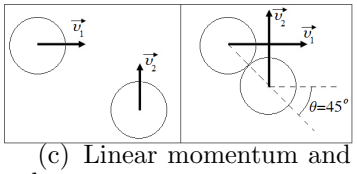
(a) 6 N (b) 9 N (c) 4.9 N (d) 4.4 N (e) 10 N

10. Calculate the force of static friction exerted by the table on the rod as it makes an angle $\theta = 37^o$ with respect to the vertical.

(a) 5.4 N (b) 3.6 N (c) 2.64 N (d) 6 N (e) 1.8 N

Questions 11-13

Two uniform identical disks of mass M and radius R collide on a frictionless table. Initial velocities of the disks are $\vec{v}_1 = v_1\hat{\imath}$ and $\vec{v}_2 = v_2\hat{\jmath}$ respectively. When the disks collide they instantly stick to each other and move as a single object. ($I_{cm} = \frac{1}{2}MR^2$)



11. Which quantities are conserved during the collision?

(a) Mechanical energy and angular momentum (b) Angular momentum and kinetic energy (c) Linear momentum and mechanical energy (d) Linear momentum and kinetic energy (e) Linear momentum and angular momentum

12. What is the velocity of center of mass of the combined disks?

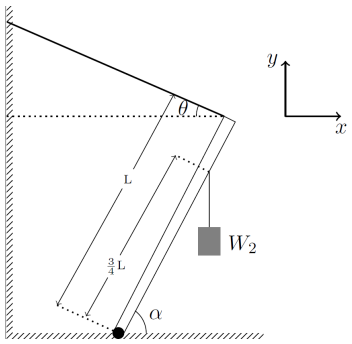
(a) $(v_1\hat{\imath}+v_2\hat{\jmath})\sqrt{2}$ (b) $(v_1\hat{\imath}-v_2\hat{\jmath})/2$ (c) $(v_1\hat{\imath}+v_2\hat{\jmath})/2$ (d) $(v_1\hat{\imath}-v_2\hat{\jmath})\sqrt{2}$ (e) $(v_1\hat{\imath}+v_2\hat{\jmath})/\sqrt{2}$

13. What is the angular velocity of the combined disks?

(a) $\frac{(v_2+v_1)}{R}\hat{k}$ (b) $\frac{(v_2-v_1)}{2R}\hat{k}$ (c) $\frac{(v_2-v_1)}{3\sqrt{2}R}\hat{k}$ (d) $\frac{2(v_2-v_1)}{R}\hat{k}$ (e) $\frac{(v_2+v_1)}{2R}\hat{k}$

Questions 14-16

A $W_1 = 1150$ N uniform rod with length L is supported by a cable perpendicular to the rod, as seen in the figure below. The rod is hinged at the bottom, and a $W_2 = 2100$ N weight hangs from its 3/4 L part. Assume the angle to be $\alpha = 60.0°$ and $\theta + \alpha = 90.0°$. The rod is in static equilibrium ($\cos 30° = 0.86$, $\sin 30° = 0.5$).



14. What is the correct statement with regard to the equilibrium of this situation?

(a) The system is in torque equilibrium but not force equilibrium.
(b) The system is in both force and torque equilibrium.
(c) The question cannot be answered with available information.
(d) The system is in force equilibrium but not torque equilibrium.
(e) The system is in neither force nor torque equilibrium.

15. What is the tension in the cable?

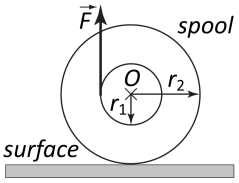
(a) 1055 N (b) 1075 N (c) 1060 N (d) 1065 N (e) 1070 N

16. What are the horizontal (H_x) and vertical (H_y) components of the force exerted on the rod by the hinge?

(a) $H_x = 924.5$ N, $H_y = 2012.5$ N (b) $H_x = 924.5$ N, $H_y = 2712.5$ N (c) $H_x = 944.5$ N, $H_y = 2712.5$ N
(d) $H_x = 934.5$ N, $H_y = 2812.5$ N (e) $H_x = 944.5$ N, $H_y = 2612.5$ N

Questions 17-18

The spool shown in the picture has total mass M, inner radius r_1, outer radius r_2, and moment of inertia I about the axis through its center O. When a vertical force $\vec{F}$ is applied to the spool by pulling on a string wrapped around the spool, the spool starts rolling on the horizontal surface without slipping.



17. What is the magnitude of the static friction force acting on the spool?

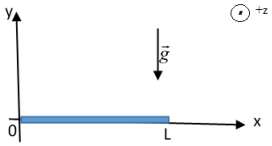
(a) $\frac{Fr_1}{r_2}$ (b) $\frac{F[I/(r_1M)+r_1]}{r_2}$ (c) $\frac{F[I/(r_2M)+r_2]}{r_1}$ (d) $\frac{Fr_2}{I/(r_1M)+r_1}$ (e) $\frac{Fr_1}{I/(r_2M)+r_2}$

18. What is the linear acceleration of the spool along the horizontal surface?

(a) $\frac{Fr_1}{Mr_2}$ (b) $\frac{F[I/(r_2M)+r_2]}{Mr_1}$ (c) $\frac{Fr_1}{M[I/(r_2M)+r_2]}$ (d) $\frac{F[I/(r_1M)+r_1]}{Mr_2}$ (e) $\frac{Fr_2}{M[I/(r_1M)+r_1]}$

Questions 19-23

A thin rod having length L and mass M is pinned at point O, so that it is free to rotate in the vertical plane. The rod is non-uniform with mass density varying as $\lambda = \lambda_0(1+\alpha x)$, where λ_0 and α are constant and limit values are known as $\lambda_{(x=0)} = \lambda_0$ and $\lambda_{(x=L)} = 2\lambda_0$.



19. Find the total mass of rod.

(a) $3\lambda_0 L/2$ (b) $2\lambda_0 L/5$ (c) $\lambda_0 L/2$ (d) $5\lambda_0 L/2$ (e) $\lambda_0 L$

20. Find the center of mass of the rod.

(a) $5L/9$ (b) $L/3$ (c) $2L/3$ (d) $3L/2$ (e) $L/2$

21. The rod is released from rest in the horizontal position at $t = 0$ s. Compute its moment of inertia.

(a) $M(\frac{5L}{9})^2 + \int_{-\frac{5L}{9}}^{\frac{4L}{9}} \lambda x^2 dx$ (b) $M(\frac{5L}{9})^2 + \int_0^L \lambda x^2 dx$ (c) $M(\frac{3L}{2})^2 + \int_0^L \lambda x^2 dx$ (d) $\int_0^L \lambda x^2 dx$ (e) $\int_{\frac{5L}{9}}^{\frac{4L}{9}} \lambda x^2 dx$

22. Find the torque about point O at $t = 0$ s.

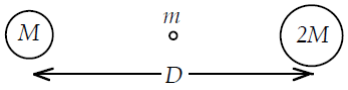
(a) $-(5MgL/9)\hat{k}$ (b) $-(MgL/3)\hat{k}$ (c) $-(3MgL/2)\hat{k}$ (d) $-(MgL/2)\hat{k}$ (e) $-(2MgL/3)\hat{k}$

23. Find the maximum kinetic energy of the system.

(a) $3MgL/2$ (b) $2MgL/3$ (c) $MgL/3$ (d) $5MgL/9$ (e) $MgL/2$

Questions 24-25

Two spherical stars with masses of M and $2M$ are positioned a distance D apart (measured from the center of one star to the center of the other star) as shown. A small spherical asteroid with mass m is located with its center exactly halfway between the two stars.



24. Find the magnitude and direction of the total gravitational force acting on the asteroid.

(a) $\frac{3GMm}{D^2}$, to the right (b) $\frac{GMm}{D^2}$, to the right (c) $\frac{2GMm}{D^2}$, to the right (d) $\frac{4GMm}{D^2}$, to the right (e) $\frac{2GMm}{D^2}$, to the left

25. Find the gravitational potential energy of the system.

(a) $-\frac{GM(3m+2M)}{D}$ (b) $-\frac{GM(m+2M)}{D}$ (c) $-\frac{GM(4m+3M)}{D}$ (d) $-\frac{GM(6m+2M)}{D}$ (e) $-\frac{GM(3m+M)}{D}$