		Surname		Type
Group Number		Name		M
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.

Questions 1-10

1. When a billiard ball is rolling on a table without sliding the friction between the ball and the table is
(a) static friction. (b) kinetic friction. (c) zero since the ball does not lose energy. (d) increasing with time. (e) decreasing with time.

2. Two one kg masses are on a ladder (on the ground), which is in equilibrium, with two supports on the ground. What is the total force acting on the ladder along +y direction?(Take $g = 10m/s^2$ and assume that the ladder is massless.)
(a) $20N$ (b) $10N$ (c) $0N$ (d) $40N$ (e) $30N$

3. Which of the followings have the max difference between center of mass and center of gravity?
(a) Trump Towers (b) A Boeing 787 plane on the air (c) A battleship (d) A tall person (e) They are the same thing

4. The dimension of the angular momentum is
(a) $[M][L]^2/[T]$. (b) $[M][L]/[T]$. (c) $[M][L]^2/[T]^2$. (d) $[M][L]/[T]^2$ (e) $[M][L]^3/[T]^2$.

5. The mass of Jupiter is around $2 * 10^{27} kg$ and its radius is around $3 * 10^5 m$. What is the approximate maximum height can a normal person jump on the surface of Jupiter? ($G = 6.67 * 10^{-11} Nm^2/kg^2$)
(a) 5 m (b) Same as earth, since we have same muscles (c) 0.05 m (d) 50 m (e) Cannot be determined from above

6. If the net force acting on a system is constant which of the following can be conserved for the system?
(a) Angular momentum (b) Linear momentum (c) Total velocity (d) Cannot be determined from above. (e) Position of the system

7. A light solid sphere and a heavier empty sphere roll down an inclined plane from the same height. Ignoring the energy loss due to friction, which of the following is correct?
(a) The lighter sphere will reach the bottom faster (b) The heavier sphere will reach the bottom faster (c) They will reach the bottom at the same time (d) Energy of the system will not be conserved (e) Momentum of the spheres will be conserved since this is a closed system

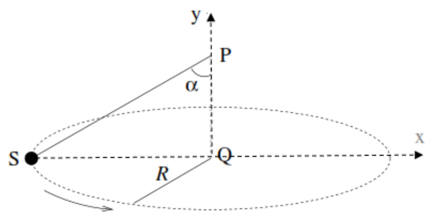
8. A disc is rotating with an initial angular speed so that the value of the period is $\sqrt{\pi}s$. One applies a constant angular acceleration for a complete turn. If the final angular speed of the disc increases so that the value of the period is $\frac{1}{2}\sqrt{\pi}s$. Calculate the angular acceleration.
(a) $3\ rad/s^2$ (b) $2\ rad/s^2$ (c) $1\ rad/s^2$ (d) $4\ rad/s^2$ (e) $5\ rad/s^2$

9. Determine the time that will take an object to move an angle d with angular acceleration b from rest.
(a) $\sqrt{2d/b}$ (b) $\sqrt{d/b}$ (c) $\sqrt{2b/d}$ (d) $\sqrt{b/d}$ (e) $\sqrt{d/(2b)}$.

10. If one doubles the mass of an object that is orbiting Jupiter what will be the ratio of its period to its initial value?
(a) 1 (b) $1/\sqrt{2}$ (c) $1/2$ (d) $\sqrt{2}$ (e) 2.

Questions 11-15

An apple of mass m is swung around on a string in a circle in a horizontal plane with a constant speed. The string makes an angle with the vertical (see the figure). The radius of the circle is R; it takes T sec for the apple to make one complete rotation; the direction of rotation is indicated in the figure; the apple, when it is at S, is coming toward you. Q is the center of the circle QP is vertical. SQ is in the +x direction, QP in the +y direction, and the +z direction is tangent to the circle at S and points toward you. The gravitational acceleration is g; assume that the string is massless. Express your answers in terms of m, R, T ,and g .



11. what is its angular speed w?
(a) $\frac{2\pi}{T}$ (b) $\frac{2\pi}{T}$ (c) $\frac{4\pi}{T}$ (d) $\frac{2\pi}{T^2}$ (e) $\frac{2\pi T}{f}$

12. What is the velocity of the apple at S (magnitude and direction)?
(a) $\frac{2\pi}{T}\hat{z}$ (b) $\frac{2\pi}{T}\hat{x}$ (c) $\frac{2\pi}{T}\hat{y}$ (d) $\frac{4\pi}{T}\hat{y}$ (e) $\frac{4\pi}{T}\hat{z}$

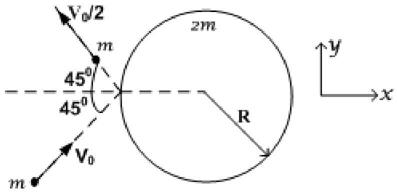
13. What is the apple's centripetal acceleration at S (magnitude and direction)?
(a) $\frac{4\pi^2 R}{T^2}\hat{x}$ (b) $\frac{4\pi^2 R}{T^2}\hat{z}$ (c) $\frac{4\pi^2 R}{T^2}\hat{y}$ (d) $\frac{4\pi R^2}{T^2}\hat{z}$ (e) $\frac{4\pi R^2}{T^2}\hat{y}$

14. At S, what is the direction and magnitude of the sum of all forces acting on the apple?
(a) $\frac{4\pi^2 mR}{T^2}\hat{x}$ (b) $\frac{4\pi^2 mR}{T^2}\hat{z}$ (c) $\frac{4\pi^2 mR}{T^2}\hat{y}$ (d) $\frac{4\pi mR^2}{T^2}\hat{z}$ (e) $\frac{4\pi mR^2}{T^2}\hat{y}$

15. What is the value of α ?
(a) $tan^{-1}[\frac{4\pi^2 R}{gT^2}]$ (b) $tan^{-1}[\frac{\pi^2 R}{gT}]$ (c) $tan^{-1}[\frac{4\pi^2 R}{gT}]$ (d) $tan^{-1}[\frac{4\pi R}{gT^2}]$ (e) $tan^{-1}[\frac{2\pi^2 R^2}{gT^2}]$

Questions 16-20

A uniform disc of mass 2m, radius R, moment of inertia $I_{km} = \frac{1}{2}(2m)R^2$ lies at rest on a frictionless (horizontal) table. A projectile of mass m and speed v_0 strikes the disc with an incident angle of 45^o and recoils with speed $\frac{1}{2}v_0$ and angle 45^o, as in the figure.



16. Which of the followings is the center of mass velocity of the disc just after the collision?
(a) $[\frac{3\sqrt{2}}{8}\hat{i} + \frac{\sqrt{2}}{8}\hat{j}]v_0$ (b) $[\frac{3}{8}\hat{i} + \frac{1}{8}\hat{j}]v_0$ (c) $\frac{3\sqrt{2}}{8}\hat{i}v_0$ (d) $[\frac{3\sqrt{2}}{4}\hat{i} + \frac{\sqrt{2}}{6}\hat{j}]v_0$ (e) $[\frac{1}{8}\hat{i} + \frac{\sqrt{2}}{8}\hat{j}]v_0$

17. Which of the followings is the angular speed of the disc just after the collision?
(a) $\frac{\sqrt{2}}{4}\frac{v_0}{R}$ (b) $\frac{1}{4}\frac{v_0}{R}$ (c) $\frac{\sqrt{2}}{8}\frac{v_0}{R}$ (d) $\frac{\sqrt{2}}{2}\frac{v_0}{R}$ (e) $\frac{1}{8}\frac{v_0}{R}$

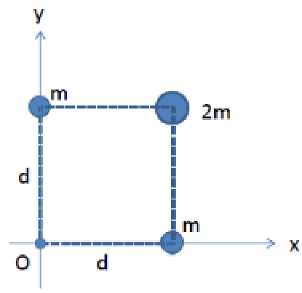
18. Which of the followings is the kinetic energy of the disc just after the collision?
(a) $\frac{3}{8}mv_0{}^2$ (b) $\frac{1}{8}mv_0{}^2$ (c) $\frac{5}{8}mv_0{}^2$ (d) $\frac{7}{8}mv_0{}^2$ (e) $mv_0{}^2$

19. What are the conserved quantities in this collision?
(a) $(\vec{p}, \vec{L_0}, K)$ (b) only $\vec{p}$ (c) $(\vec{p}, \vec{L_0}, K)$ (d) $(\vec{p}, K)$ (e) $(\vec{L_0}, K)$

20. If the mass m sticks to the disc after the collision, which of the followings is the angular speed of the combined system just after the collision?
(a) $\frac{\sqrt{2}}{5}\frac{v_0}{R}$ (b) $\frac{\sqrt{2}}{7}\frac{v_0}{R}$ (c) $\frac{1}{4}\frac{v_0}{R}$ (d) $\frac{\sqrt{2}}{4}\frac{v_0}{R}$ (e) $\frac{1}{7}\frac{v_0}{R}$

Questions 21-25

Three uniform spheres with masses m, m and 2m are fixed at the positions shown in the figure (Take G as the universal constant). 1 kg mass is located at the origin.



21. What is the magnitude and the direction of the gravitational force on 1 kg mass due to the particle at (0,d)?
(a) $Gm/d^2\hat{j}$ (b) $Gm/d^2\hat{i}$ (c) $Gm/d\hat{i}$ (d) $Gm/d\hat{j}$ (e) $Gm/d^2(\hat{i} + \vec{j})$

22. What is the magnitude and the direction of the gravitational force on 1 kg mass due to the particle at (d,0)?
(a) $Gm/d^2\hat{i}$ (b) $Gm/d^2\hat{j}$ (c) $Gm/d\hat{i}$ (d) $Gm/d\hat{j}$ (e) $Gm/d^2(\hat{i} + \vec{j})$

23. What is the magnitude and the direction of the gravitational force on 1 kg mass due to the particle at (d,d)?
(a) $\frac{G2m}{(d\sqrt{2})^2}Sin45^o\hat{i} + \frac{G2m}{(d\sqrt{2})^2}Cos45^o\hat{j}$ (b) $-\frac{G2m}{(d\sqrt{2})^2}Cos45^o\hat{i} + \frac{G2m}{(d\sqrt{2})^2}Sin45^o\hat{j}$ (c) $\frac{G2m}{(d\sqrt{2})^2}Sin45^o\hat{i} - \frac{G2m}{(d\sqrt{2})^2}Sin45^o\hat{j}$
(d) $-\frac{G2m}{(d\sqrt{2})^2}Cos45^o\hat{i} - \frac{G2m}{(d\sqrt{2})^2}Cos45^o\hat{j}$ (e) none of them

24. What is the magnitude and the direction of the total gravitational force on 1 kg mass due to these three particles?
(a) $\frac{Gm}{d^2}(1 + \frac{\sqrt{2}}{2})\hat{i} + \frac{Gm}{d^2}(1 + \frac{\sqrt{2}}{2})\hat{j}$ (b) $\frac{Gm}{(2d)^2}(1 + \frac{\sqrt{2}}{2})\hat{i} + \frac{Gm}{(2d)^2}(1 + \frac{\sqrt{2}}{2})\hat{j}$ (c) $\frac{G2m}{d^2}(1 + \frac{\sqrt{2}}{2})\hat{i} + \frac{G2m}{d^2}(1 + \frac{\sqrt{2}}{2})\hat{j}$
(d) $\frac{G2m}{(2d)^2}(1 + \frac{\sqrt{2}}{2})\hat{i} + \frac{G2m}{(2d)^2}(1 + \frac{\sqrt{2}}{2})\hat{j}$ (e) none of them

25. Suppose that the particle of mass of 2m is now removed. Where could this particle (mass of 2m) be placed to make the net gravitational field at the origin equal to zero?
(a) **none of them** (b) $d\sqrt{2}(\hat{i} - \hat{j})$ (c) $d\sqrt{2}(\hat{i} + \hat{j})$ (d) $-d\sqrt{2}(\hat{i} + \hat{j})$ (e) $d\sqrt{2}(-\hat{i} + \hat{j})$