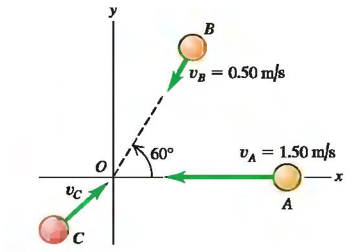
		Surname		Type
Group Number		Name		A
List Number		e-mail		
Student ID		Signature		

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.

Questions 1-4

Three particles A (mass 0.020 kg), B (mass 0.030kg), and C (mass 0.050 kg) are approaching the origin as they slide on a frictionless air table shown in figure. The initial velocities of A and B are given in the figure. All three particles arrive at the origin at the same time and stick together. If all three particles are to end up moving at 0.50 m/s in the +x direction after the collision; (cos60=0.5 and sin60=0.86)



1. Which quantity(ies) will be conserved during this collision?
(a) nothing (b) x and y components of momentum (c) kinetic energy (d) x component of momentum (e) y component of momentum

2. What must the x component of the initial velocity of particle C ?
(a) 0 (b) 3 (c) 1.75 (d) 2.5 (e) 0.5

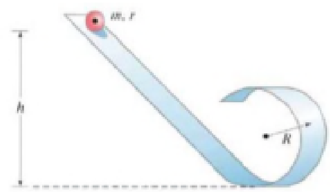
3. What must the y component of the initial velocity of particle C ?
(a) 1.5 (b) 2.5 (c) 0.26 (d) 3 (e) 0.9

4. What is the change in the kinetic energy of particle B as a result of the collision?
(a) 0.77 (b) 1.77 (c) -1.5 (d) 0 (e) 0.092

5. If the net force acting on a system is zero, is the net torque also zero? If the net torque acting on a system is zero, is the net force zero?
(a) No, No (b) Yes, No (c) None (d) No, Yes (e) Yes, Yes

Questions 6-8

A marble of mass m and radius r rolls along the looped rough track of Figure in the right:



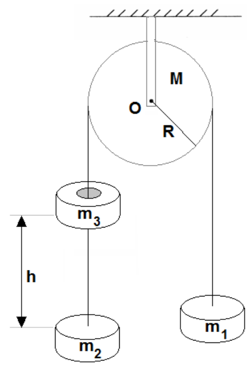
6. Assuming r << R, what is the minimum value of the vertical height h that the marble must drop if it is to reach the highest point of the loop without leaving the track?
(a) 2.6R (b) 2.8R (c) 2.9R (d) 2.7R (e) 2.5R

7. By what factor of R would provide half of the vertical height?
(a) 5/27 (b) 10/27 (c) 5/54 (d) 54/5 (e) 27/5

8. Without the assumption, what is the minimum value of the vertical height h that the marble must drop if it is to reach the highest point of the loop without leaving the track?
(a) 2.5(R-r) (b) 2.7(R-r) (c) 2.8(R-r) (d) 2.9(R-r) (e) 2.6(R-r)

Questions 9-12

While the Atwood machine shown in the figure is at rest, mass m_3 is released from a height h=0.2 m above the mass m_2. m_2 and m_3 stick together after collision. Acceleration due to gravity is g=10 m/s^2, $m_1 = m_2 = m_3 = 3$ kg, the mass and radius of the pulley are M=6 kg and R=0.15 m. The pulley rotates about a frictionless axle and has a moment of inertia $I_o = MR^2/2$. The cord does not slip on the pulley.



9. Which of the following is/are the conserved quantity/quantities during the collision?
(a) total angular momentum with respect to point O and the mechanical energy
(b) total angular momentum with respect to point O
(c) total angular momentum with respect to point O and the linear momentum
(d) mechanical energy
(e) linear momentum

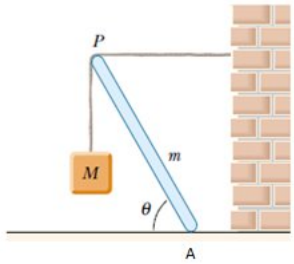
10. What is the speed of m_1 just after the collision?
(a) 2 m/s (b) 2/3 m/s (c) 1 m/s (d) 0.4 m/s (e) 0.5 m/s

11. Just after the collision, what is the magnitude of the angular momentum of m_1 with respect to m_2?
(a) 1.2 kg m^2/s (b) 0.9 kg m^2/s (c) 0.225 kg m^2/s (d) 1.8 kg m^2/s (e) 0.72 kg m^2/s

12. What is the acceleration of m_1 after the collision?
(a) 6 m/s^2 (b) 5 m/s^2 (c) 2 m/s^2 (d) 2.5 m/s^2 (e) 10/3 m/s^2

Questions 13-16

A uniform beam of mass m and length L is inclined at an angle θ to the horizontal. Its upper end produces a 90° bend in a very rough rope tied to a wall, and its lower end rest on a rough floor.



13. What is the value of torque about point A?

(a) (M+m)sinθL (b) MgLcosθ-mgLcosθ/2 (c) MgL+mgl/2 (d) 0 (e) Mgsinθ-mgcosθ

14. Determine an expression for the maximum mass M that can be suspended from the top before the beam slips, when the coefficient of static friction between the beam and the floor is $\mu_s < \cot\theta$.

(a) $\frac{m\mu_s}{2}$ (b) $\frac{m}{2}\left(\frac{2\mu_s\cos\theta-\sin\theta}{\mu_s\sin\theta}\right)$ (c) $\frac{m}{4}\left(\frac{2\mu_s\sin\theta}{\cos\theta-\mu_s\sin\theta}\right)$ (d) $\frac{m}{4}$ (e) $\frac{m}{2}\left(\frac{2\mu_s\sin\theta-\cos\theta}{\cos\theta-\mu_s\sin\theta}\right)$

15. Determine an expression for the maximum mass M that can be suspended from the top before the beam slips, when the coefficient of static friction between the beam and the floor is $\mu_s > \cot\theta$.

(a) M can increase without limit (b) $\frac{m}{2}\left(\frac{2\mu_s\cos\theta-\sin\theta}{\mu_s\sin\theta}\right)$ (c) m (d) $\frac{m}{2}\left(\frac{2\mu_s\sin\theta-\cos\theta}{\cos\theta-\mu_s\sin\theta}\right)$
(e) $\frac{m}{4}\left(\frac{2\mu_s\sin\theta}{\cos\theta-\mu_s\sin\theta}\right)$

16. Determine the magnitude of the reaction force at the floor in terms of m, M, and μ_s, when the coefficient of static friction between the beam and the floor is $\mu_s < \cot\theta$.

(a) $g\sqrt{m^2+\mu_s^2(M+m)^2}$ (b) $g\sqrt{M^2\sin\theta+\mu_s^2(M+m)^2\cos\theta}$ (c) $g\sqrt{Mm+\mu_s^2(M+m)^2}$ (d) $g\sqrt{M^2+\mu_s^2(M+m)^2}$
(e) $g\sqrt{\frac{M^2\sin\theta+\mu_s^2(M+m)^2\cos\theta}{m^2\cos\theta-\mu_s^2M\sin\theta}}$

17. What is the relation between the total mechanical energy E and potential energy U 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.

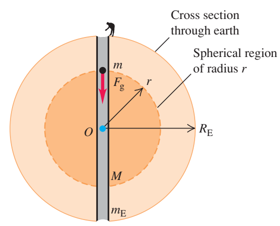
(a) $E = U$ (b) $U = 2E$ (c) $E = -2U$ (d) $U = -2E$ (e) $E = 2U$

18. Your personal spacecraft is in a low-altitude circular orbit around the earth. Air friction from the atmosphere does negative work on the spacecraft, causing the orbital radius to decrease slightly. What happens to the speed of your spacecraft?

(a) The answer depends on the original radius of the orbit (b) The answer depends on the ratio of masses of the spacecraft and the earth (c) It decreases (d) It remains the same (e) It increases

Questions 19-20

Imagine that you drill a hole through the earth along a diameter and drop a ball down the hole as shown in the figure. Assume that the earth's density is uniform and the earth is perfectly spherical. m_E and R_E are the mass and radius of the earth respectively, m is the mass of the ball, r is the distance from the center, M is the mass in the spherical region of radius r.



19. What is the expression for the gravitational force F_g on the ball as a function of its distance from the earth's center?

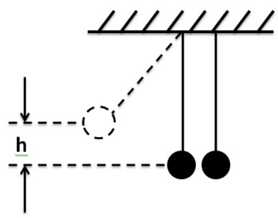
(a) $F_g = \frac{Gm_Em}{R_E^2}\frac{R_E}{r}$ (b) $F_g = 0$ (c) $F_g = \frac{Gm_Em}{R_E^2}\frac{r^2}{R_E^2}$ (d) $F_g = \frac{Gm_Em}{R_E^2}\frac{r}{R_E}$ (e) $F_g = \frac{Gm_Em}{R_E^2}\frac{R_E^2}{r^2}$

20. What is the acceleration a of the ball at the instant when the ball reached the center of the earth? Assume that there isn't any friction force exerting on the ball.

(a) $a = 9.8\,\mathrm{km/s^2}$ (b) Infinitely large (c) $a = 0$ (d) Cannot be known since the initial speed of the ball is not given (e) $a = 9.8\,\mathrm{m/s^2}$

Questions 21-25

In Figure, both balls have the same mass. The ball on the left is displaced to the outlined position and released; it collides with the stationary ball and sticks to it.



21. How fast are the balls moving just after collision?

(a) $2gh$ (b) $\sqrt{2gh}$ (c) $\sqrt{gh}$ (d) $\sqrt{3gh}$ (e) $2\sqrt{gh}$

22. What fraction of its kinetic energy did the first ball lose in the collision?

(a) %100 (b) %75 (c) %25 (d) %40 (e) %50

23. Suppose the two balls in figure have different masses; the ball on the left has m_1. When it is let go from the height shown, it hits the second ball and sticks to it. The combination then swings to a height h/9. Find the mass m_2 of second ball in terms of m_1

(a) $m_2=2m_1$ (b) $m_2=4m_1$ (c) $m_2=3m_1$ (d) $m_2=(1/2)m_1$ (e) $m_2=(3/2)m_1$

24. In figure, these two balls having different masses are displaced to a height h, one to the left and the other to the right. They are released simultaneously and undergo a perfectly elastic collision (it is assumed) at the bottom. How high does each swing after the collision?

(a) $V_{1f} = 2\sqrt{2gh}$, $V_{2f} = \sqrt{2gh}$ (b) $V_{1f} = -(5/3)\sqrt{2gh}$, $V_{2f} = (1/3)\sqrt{2gh}$ (c) $V_{1f} = (4/3)\sqrt{2gh}$, $V_{2f} = \sqrt{2gh}$
(d) $V_{1f} = \sqrt{2gh}$, $V_{2f} = \sqrt{2gh}$ (e) $V_{1f} = -(2/3)\sqrt{2gh}$, $V_{2f} = \sqrt{2gh}$

25. Using the result of (23), the mass on the left (m_1) in figure is pulled aside and released. Its velocity at the bottom is v_0 just as it collides with the ball on the right (m_2) in a perfectly elastic collision. Find the velocities of two balls just after collision.

(a) $V_{1f} = -(1/3)v_0$, $V_{2f} = (2/3)v_0$ (b) $V_{1f} = -v_0$, $V_{2f} = v_0$ (c) $V_{1f} = -2v_0$, $V_{2f} = (1/3)v_0$ (d) $V_{1f} = -(1/2)v_0$, $V_{2f} = (1/3)v_0$ (e) $V_{1f} = -(1/3)v_0$, $V_{2f} = (1/3)v_0$