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**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.** Which of the following statements are correct about the direction of the unit vector in the Universal Law of Gravitation defined as $\overrightarrow{F} = -G\frac{m_1 m_2}{r^2}\hat{r}$.
**1.** From the source to the object. **2.** From the object to the source. **3.** How it is selected does not matter.
(a) Only 3 (b) All are correct (c) None of this is true (d) Only 2 (e) Only 1

**2.** The expression $a_c R^2 = k$ was found to be valid for each of the planets around the Sun. Here $a_c$ and $R$ are the centripetal acceleration and the average radius, respectively, and $k$ is a constant. Which of the Newton's laws should be considered in conjunction with this statement to obtain the universal law of gravitation?
**1.** Action-reaction law **2.** The second law **3.** The law of inertia
(a) 1 and 2 (b) Only 2 (c) 1 and 3 (d) All are true (e) 2 and 3

**3.** The statement "A planet around the Sun sweeps equal areas in equal time intervals" (Kepler's law) can be proved by..
(a) Conservation of the energy (b) Conservation of the angular momentum (c) Conservation of the momentum (d) Newton's second law (e) Newton's law of inertia

**4.** While recognizing that the planets around the Sun can turn in nearly circular orbits, which of the followings expresses the linear velocity of the planet in terms of the radius of the orbit, R and the return period of the planet, T?
(a) $\frac{2\pi R^2}{T^2}$ (b) $\frac{R}{T}$ (c) $\frac{4\pi^2 R^2}{T^3}$ (d) $\sqrt{\frac{4\pi^2 R^2}{T^3}}$ (e) $\frac{2\pi R}{T}$

**5.** Which of the following is true for a planet rotating around the Sun in elliptical orbits.
(a) The planet's orbital speed does not change. (b) The speed of the planet is maximum when the planet is farthest from the sun. (c) The speed of the planet is minimum when the planet is closest to the sun. (d) Planets closer to the Sun orbital speed increases. (e) Planets closer to the Sun orbital speed decreases.

**6.** Which of the following is wrong about the rotational inertia of a rigid body?
(a) It depends on the shape of the object. (b) Increases with increasing speed. (c) Increases with increasing distance to the rotation axis. (d) It does not depend on angular speed. (e) Increases with increasing mass.

**7.** A particle of mass $m$ moves along a straight line with an acceleration that is non-zero. Where can an axis be located such that the angular momentum of the particle is <u>not</u> constant?
(a) Any point on the path of the particle. (b) Initial point of the particle. (c) Any point not on the path of the particle. (d) There are no such points. (e) A point that is instantaneously at the location of the particle.

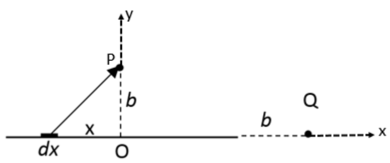
**8.** For a rigid body in equilibrium which of the following is wrong?
(a) It may have a constant angular velocity. (b) The only point with respect to which the net torque is zero is the center of mass of the body. (c) The net external force acting on the object is zero. (d) The angular acceleration is zero. (e) It may have a constant velocity.

**9.** The escape speed from a planet of mass $M$ and radius $R$ is $v$. What is the escape speed from a planet of mass $2M$ and radius $R/2$?
(a) $v$ (b) $2v$ (c) $4v$ (d) $v/2$ (e) $\sqrt{2}v$

**10.** If the total momentum of a system of particles is zero, which of the following is wrong?
(a) The net impuls is zero. (b) All of the particles in the system can be at rest. (c) Center of mass velocity of the system is zero. (d) The total kinetic energy of the system is certainly zero. (e) The net external force acting on the system is zero.

**Soru 11-15**

A thin wire of the length L and the mass M is fitted to the x-axis as shown in the figure. The mid-point of the wire is located at the center, O, of the coordinate system, The point P is located at a distance $y = b$ above the midpoint of the wire. And the point Q is located at a distance b from the rigth end of the wire.




**11.** Which of the following expresses the mass, $dm$, of an infinitesimal length, $dx$, choosen along the wire?
(a) $dm = \frac{2M}{3L}dx$ (b) $dm = \frac{M}{L}dx$ (c) $dm = \frac{2M}{L}dx$ (d) $dm = \frac{M}{2L}dx$ (e) $dm = \frac{3M}{2L}dx$

**12.** What is the gravitational field of $d\vec{g}$ created by dm at the point $P$? Here $dm$ is choosen at a distance $x$ at the left of the point O as shown in the figure.
(a) $d\vec{g} = -G\frac{bdm}{(x^2+b^2)}\hat{j}$ (b) $d\vec{g} = -G\frac{dm}{(x^2+b^2)}(x\hat{i} + b\hat{j})$ (c) $d\vec{g} = -G\frac{dm}{(x^2+b^2)^{3/2}}(x\hat{i} - b\hat{j})$ (d) $d\vec{g} = -G\frac{dm}{(x^2+b^2)^{3/2}}(x\hat{i} + b\hat{j})$
(e) $d\vec{g} = -G\frac{xdm}{(x^2+b^2)^{3/2}}\hat{i}$

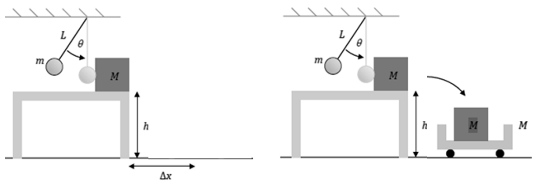
**13.** What is the net gravitational field created by the wire at the point P?
(a) $\vec{g} = -\frac{GM}{L}\int_{-L/2}^{+L/2}\frac{x\,dx}{(x^2+b^2)^{3/2}}\hat{j}$ (b) $\vec{g} = -\frac{GM}{L}\int_{0}^{+L/2}\frac{x\,dx}{(x^2+b^2)^{3/2}}\hat{i}$ (c) $\vec{g} = -\frac{GM}{L}\int_{0}^{L}\frac{b\,dx}{(x^2+b^2)^{3/2}}\hat{j}$ (d) $\vec{g} = -\frac{GM}{L}\int_{-L/2}^{+L/2}\frac{b\,dx}{\sqrt{x^2+b^2}}\hat{j}$
(e) $\vec{g} = -\frac{GM}{L}\int_{-L/2}^{+L/2}\frac{b\,dx}{(x^2+b^2)^{3/2}}\hat{j}$

**14.** What is the net gravitational field at a distance b from the right end of the wire, the point Q?
(a) $\vec{g} = -\frac{GM}{L}\int_{0}^{L}\frac{dx}{(x+b)^{3/2}}\hat{i}$ (b) $\vec{g} = -\frac{GM}{L}\int_{-L/2}^{+L/2}\frac{x\,dx}{(x+b)^2}\hat{i}$ (c) $\vec{g} = -\frac{GM}{L}\int_{-L/2}^{L/2}\frac{dx}{(\frac{L}{2}+b-x)^2}\hat{i}$ (d) $\vec{g} = -\frac{GM}{L}\int_{-L/2}^{+L/2}\frac{dx}{(x+b)^2}\hat{i}$
(e) $\vec{g} = -\frac{GM}{L}\int_{0}^{L}\frac{b\,dx}{(x+b)^2}\hat{i}$

**15.** What is the gravitational force on a small particle of mass m located at the point P?
(a) $\vec{g} = -\frac{GMm}{L}\int_{0}^{L}\frac{b\,dx}{(x^2+b^2)}\hat{j}$ (b) $\vec{g} = -\frac{GMm}{L}\int_{-L/2}^{+L/2}\frac{b\,dx}{\sqrt{x^2+b^2}}\hat{j}$ (c) $\vec{g} = -\frac{GMm}{L}\int_{-L/2}^{+L/2}\frac{x\,dx}{(x^2+b^2)}\hat{j}$ (d) $\vec{g} = -\frac{GMm}{L}\int_{-L/2}^{+L/2}\frac{b\,dx}{(x^2+b^2)^{3/2}}\hat{j}$
(e) $\vec{g} = -\frac{GMm}{L}\int_{0}^{+L/2}\frac{x\,dx}{(x^2+b^2)^{3/2}}\hat{i}$

**Soru 16-20**

A pendulum of length $L = 1.0\ m$ and bob with mass $m = 1.0\ kg$ is released from rest at an angle $\theta = 30^o$ from the vertical. When the pendulum reaches the vertical position, the bob strikes a mass $M = 3.0\ kg$ that is resting on a frictionless table that has a height $h = 20\ m$, in the figure. $Cos30 = 0.8$, $Sin30 = 0.5$, $g = 10\ m/s^2$




**16.** When the pendulum reaches the vertical position, calculate the speed of the bob ($m/s$) just before it strikes the box.
(a) 2 (b) 3 (c) 1 (d) 5 (e) 4

**17.** Calculate the speed of the box ($m/s$) just after they collide elastically.
(a) $-2$ (b) 2 (c) 1 (d) $-1$ (e) 0

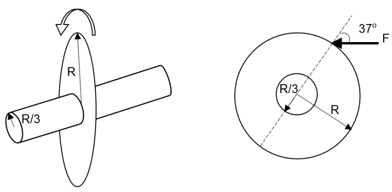
**18.** Calculate the speed of the the bob ($m/s$) just after they collide elastically.
(a) $-1$ (b) 1 (c) $-2$ (d) 2 (e) 0

**19.** Determine how far away from the bottom edge of the table, $\Delta x$ (m), the box will strike the floor.
(a) 2 (b) 4 (c) 5 (d) 1 (e) 3

**20.** At the location where the box would have struck the floor, now a small cart of mass $M = 3.0\ kg$ and negligible height is placed. The box lands in the cart and sticks to the cart in a perfectly inelastic collision. Calculate the horizontal velocity of the cart ($m/s$) just after the box lands in it.
(a) 2/3 (b) 1/2 (c) 2 (d) 1 (e) 1/3

**Questions 21-25**

A disk of mass $M$ and radius $R$ is mounted on a rough horizontal cylindrical axle of radius $R/3$, as shown in the figure. There is a friction force between the disk and the axle. A constant force of magnitude $F$ is applied to the edge of he disk at an angle of $37.0^o$. After $3.00\ s$, the force is reduced to $F/5$, and the disk spins with constant angular speed after this instant. (For a disk of inner radius $R_1$ and outer radius $R_2$, $I_{cm} = \frac{1}{2}M(R_2^2 - R_1^2)$. $sin37 = 3/5$.)




**21.** What is the magnitude of the torque with respect to the center of the disk due to friction between the disk and the axle?
(a) $4FR/25$ (b) $3FR/25$ (c) $3FR/23$ (d) $4FR/27$ (e) $3FR/17$

**22.** What is the angular velocity of the disk at $t = 3.00\ s$?
(a) $\frac{81}{25}\frac{F}{MR}$ (b) $\frac{75}{26}\frac{F}{MR}$ (c) $\frac{81}{29}\frac{F}{MR}$ (d) $\frac{63}{25}\frac{F}{MR}$ (e) $\frac{67}{25}\frac{F}{MR}$

**23.** What is the kinetic energy of the disk at $t = 2.00\ s$?
(a) $\frac{457}{625}\frac{F^2}{M}$ (b) $\frac{677}{625}\frac{F^2}{M}$ (c) $\frac{648}{625}\frac{F^2}{M}$ (d) $\frac{717}{625}\frac{F^2}{M}$ (e) $\frac{217}{625}\frac{F^2}{M}$

**24.** What is the rate of change of the angular momentum of the system with respect to the center of mass of the disk, $\frac{d\vec{L}}{dt}$, at $t = 2.00\ s$?
(a) $\frac{113}{25}FR$ (b) $\frac{4}{5}FR$
(c) $\frac{11}{25}FR$ (d) $\frac{12}{25}FR$ (e) $\frac{17}{25}FR$

**25.** What is the rate of change of the angular momentum of the system with respect to the center of mass of the disk, $\frac{d\vec{L}}{dt}$, at $t = 4.00\ s$?
(a) $2FR/5$ (b) $3FR/5$ (c) $FR$ (d) $4FR/5$ (e) 0