S.No.	Question Details-System of Particles		Marks
	MCQ		
1.	For increasing the angular velocity of an object by 10%, the kinetic energy has to be increased by		**1**
	(a) 40%	(b) 20%	
	(c) 10%	(d) 21%	
2.	The total energy of rolling ring of mass ‘m’ and radius ‘R’		**1**
	(a) $3/2\ mv^2$	(b) $1/2\ mv^2$	
	(c) mv^2	(d) $5/2\ mv^2$	
3.	Four-point masses, each of value m, are placed at the corners of a square ABCD, having each side of length L. what the moment of inertia of this system about an axis is passing through A and parallel to the diagonal BD?		**1**
	(a) $3mL^2$	(b) $2\ mL^2$	
	c) $\sqrt{3}\ mL^2$	(d) mL^2	
4.	A dancer on ice spins faster when she folds here arms. This is due to		**1**
	(a) Increases in energy and increase in angular momentum	(b) Decrease in friction at the skates	
	(c)Constant angular momentum and increase in kinetic energy	(d) Increase in energy and decreases in angular momentum	
5.	Moment of inertia of a disc about an axis which is tangent and parallel to its plane is I ,then the moment of inertia of disc about a tangent ,but perpendicular to its plane will be		**1**
	(a) $\frac{3I}{4}$	(b) $\frac{3I}{2}$	
	(c) $\frac{5I}{6}$	(d) $\frac{6I}{5}$	
6.	When a body rolls down an inclined plane, its potential energy is converted in to		
	(a) translational K.E only	(b) Rotational K.E only	
	(c) Translational and rotational K.E	(d) none of the above	

7.	Two solid cylinders P and Q of the same mass and same radius start rolling down a fixed inclined plane from the same height at the same time .Cylinder P has most of its mass concentrated near the surface , while Q has most of its mass concentrated near the axis. Which of the following statements given below is correct?		**1**
	(a) Both cylinders P and Q reach the ground at the same time	(b) Cylinder P has larger linear acceleration than cylinder Q	
	(c) Both cylinders reach the ground with same translational kinetic energy	**(d)** Cylinder Q reaches the ground with larger angular speed	
9.	The moment of inertia of a thin rod of mass M and length L about an axis passing through the point at a distance L/4 from one of its ends and perpendicular to the rod is _____		**1**
	(a) $(7ML^2)/48$	(b) $(ML^2)/ 12$	
	(c) $)(ML^2)/ 9$	(d) $(ML^2)/ 3$	
10.	The ratio of the radii of gyration of a circular disc and a circular ring of the same masses and radii about a tangential axis parallel to the their planes is		**1**
	(a) $\sqrt{6} : \sqrt{5}$	(b) $1 : \sqrt{2}$	
	(c) $\sqrt{5} : \sqrt{6}$	(d) none of these	
11.	A particle performs uniform circular motion with an angular momentum L. If the frequency of the particle motion is doubled and its kinetic energy is halved, the angular momentum becomes		**1**
	(a) L/4	(b) L/2	
	c) 2 L	d) 4L	
12	The angular velocity of second's hand in a watch is ….		**1**
	a) 0.82 rad/sec	b) 0.105 rad/sec	
	c)0.21 rad/sec	d)0.052 rad/sec	
13	A raw egg and a boiled egg are made to spin on a table with same angular speed about the same axis. The ratio of time taken by the two to stop is		**1**
	=1	>1	
	<1	None of the above	

14	A wheel of radius R rolls on the ground with uniform velocity v . The velocity of topmost point relative to bottom most point		**1**
	(a) 0	(b)2v	
	(c) v	(d)v/2	
15.	**Assertion :** If polar ice melts, days will be longer. **Reason :** Moment of inertia decreases and thus angular velocity increases.		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
16.	**Assertion :** A wheel moving down a frictionless inclined plane will slip and not roll on the plane. **Reason :** It is the frictional force which provides a torque necessary for a body to roll on a surface.		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
17	**Assertion:** The total kinetic energy of a rolling solid sphere is the sum of translational and rotational kinetic energies. **Reason :** For all solid bodies total kinetic energy is always twice the translational kinetic energy.		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
18	**Assertion :** The center of mass of a two particle system lies on the line joining the two particle, being closer to the heavier particle. **Reason :** Product of mass of particle and its distance from center of mass is numerically equal to product of mass of other particle and its distance from center of mass.		**1**

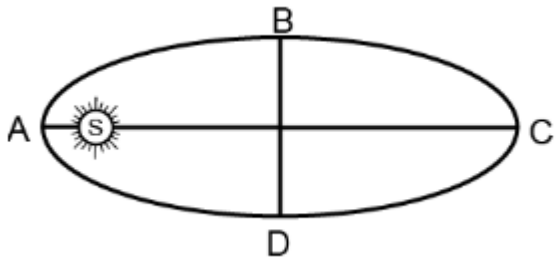
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
19	**Assertion:** The earth is slowing down and as a result the moon is coming nearer to it. **Reason :** The angular momentum of the earth moon system is conserved.		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
20.	A disc of metal is melted and recast in the form of a solid sphere. What will happen to the moment of inertia about a vertical axis passing through center?		**1**
21.	A cap of pen can be easily opened with the help of two fingers than one finger. Why?		**1**
22.	Why does a pilot not fall down when his aero plane takes a vertical loop?		**1**
23.	A circular ring, and a disc have same mass and radius. Which has larger moment of inertia?		**1**
24.	Two solid spheres of the same mass are made of metals of different densities. Which of them has a larger moment of inertia about a diameter?		**1**
25.	From a complete ring of mass M and radius R, an arc making 30° at the centre is removed. What is the moment of inertia of the incomplete ring about an axis passing through the centre of the ring and perpendicular to the plane of ring? ($11/12\ MR^2$)		**2**
26.	A thin uniform circular disc of Mass M and radius R is rotating in a horizontal plane about an axis passing through its center and perpendicular to its plane with an angular velocity **ώ**. Another disc of the same dimensions but of Mass M/4 is placed gently on the first disc co-axially. Show that angular velocity of the system is 4/5 **ώ.**		**2**
27.	If L and Ekr, represent the angular momentum and the rotational kinetic energy respectively of a body , then what is the shape of the graph between L and Ekr?		**2**
28.	How will you distinguish a hard-boiled egg from a raw egg by spinning each on a tabletop?		**2**
29.	The moments of inertia of two rotating bodies A and B are IA and IB (IA > IB) and their angular momenta are equal. Which one has greater K.E.?		**2**
30.	Four particles A,B,C,D of masses m,2m,3m,4m respectively are placed at corners of a square of side x. Locate the centre of mass .		**2**

31.	A torque of 20N-m is applied on a wheel initially at rest. Calculate the angular momentum of the wheel after 3 sec.	**2**
31.	Why do we prefer to use a wrench with a long arm?	**2**
32.	Two circular discs A and B of the same mass and same thickness are made of two different metals whose densities are $\mathbf{d_A}$ and $\mathbf{d_B}$ ($\mathbf{d_A > d_B}$**).** Their moments of inertia about the axes passing through their centre of gravity and perpendicular to their planes are $\mathbf{I_A}$ and $\mathbf{I_B}$**.** Which is greater, $\mathbf{I_A}$ **or** $\mathbf{I_B}$**.** Give reason?	**2**
33.	Three masses 3 kg, 4 kg and 5 kg are located at the corners of an equilateral triangle of side 1m. Locate the centre of mass of the system.	**2**
34	A uniform ring of mass 10 kg and diameter 0.40m rotates with a uniform speed of 2100 rotations per min. Find the moment of inertia and angular momentum of the ring about its geometric axis.	**2**
35	Three identical spheres each of radius r, and mass m are placed touching each other on a horizontal floor. Locate the position of center of mass of the system.	**2**
36	A point mass (m= 0.2 kg) is rotating in a horizontal circle of radius 10 cm with a frequency of ($5/\pi$) revolutions/second. Calculate the angular momentum and kinetic energy of the particle.	**2**
37	What will be the duration of the day, if the earth suddenly shrinks to 1/64 of its original volume, mass remaining unchanged? moment of inertia of sphere = $(2/5)\ MR^2$	**2**
38	Energy of 484 joule is spent in increasing speed of a flywheel from 60 rpm to 360 rpm. Calculate the moment of inertia of the wheel.	**2**
39	The moment of inertia of a uniform circular disc about its diameter is 100 g/cm^2. What is its moment of inertia (i) about a tangent in the plane of the disc (ii) about its central axis perpendicular to the plane of the disc?	**2**
40	A diver having a moment of inertia of 6.0 kgm^2 about an axis through its center of mass rotates at an angular speed of 2 rad/s about this axis. If he folds his hands and feet to decrease the moment of inertia to 5.0 kgm^2, What will be the new angular speed?	**2**
41.	Determine the acceleration of a body rolling down an inclined plane without slipping. What is the minimum value of coefficient of friction required for the body to roll without slipping?	**3**
42.	A solid sphere rolls down two different inclined planes of the same heights but different angles of inclination. (a) Will it reach the bottom with the same speed in each case? (b) Will it take longer to roll down one plane than the other? (c) If so, which one and why?	**3**

43.	Derive an expression for the rotational kinetic energy and hence define moment of inertia. Explain its physical significance.	**3**
44.	Define angular momentum. Show that the angular momentum is equal to twice the product of mass and areal velocity.	**3**
45.	Define angular acceleration and torque. Establish the relation between (i) angular acceleration and torque (ii) angular momentum and torque	**3**
46.	**a)** A body start to roll down an inclined plane of height **h**. Prove that the velocity **v** of translation of a rolling body at the bottom of the inclined plane is given by $\mathbf{v^2 = 2gh/(1+k^2/R^2)}$ **b)** What is the force of friction after perfect rolling begins? **c)**A solid sphere rolls down two different inclined planes of the same height **,** but of different inclinations **(i)**Will it reach the bottom with the same speed in each case? **(ii)** Will it take the same time to roll down? Give reason in each case?	**3**
47	CASE STUDY 1In physics, **angular momentum** (sometimes called **moment of momentum** or **rotational momentum**) is the rotational analog of linear momentum. It is an important physical quantity because it is a conserved quantity – the total angular momentum of a closed system remains constant. Similar to conservation of linear momentum, where it is conserved if there is no external force, angular momentum is conserved if there is no external torque. Torque can be defined as the rate of change of angular momentum, analogous to force. The net *external* torque on any system is always equal to the *total* torque on the system; in other words, the sum of all internal torques of any system is always 0 (this is the rotational analogue of Newton's third law of motion). Therefore, for a *closed* system (where there is no net external torque), the *total* torque on the system must be 0, which means that the total angular momentum of the system is constant. The change in angular momentum for a particular interaction is sometimes called **twirl**, but this is quite uncommon. Twirl is the angular analog of impulse. **(i)** When there is no external torque acting on a rotating body, which of the following quantities can change (i)angular acceleration (ii)angular momentum (iii)Angular speed? **(ii)** If L and Ekr , represent the angular momentum and the rotational kinetic energy respectively of a body , then what is the shape of the graph between L and Ekr? **(iii)**When the ice on the polar caps of earth melts, what happens to the duration of the day &why? OR (iii)A planet comes closer to the sun angular velocity increases Why?	**4**

48	CASE STUDY 2 Read the following passage and choose appropriate answers of questions 1 to 4. The rotational analogue of force in linear motion is moment of force. It is also referred to as torque or couple. If a force acts on a single particle at a point, whose position with respect to the origin is given by the position vector r, the moment of the force acting on the particle with respect to the origin is defined as the vector product $\tau = r \times F$ The moment of force (or torque) is a vector quantity. The magnitude of is $\tau = r F \sin\theta$ Where $r\sin\theta$ is the perpendicular distance of the line of action of F from the origin and $F \sin\theta$ is the component of F in the direction perpendicular to r. Note that $\tau = 0$ if $r = 0$, $F = 0$ or $\theta = 0^0$ or 180^0 . Thus, the moment of a force vanishes if either the magnitude of the force is zero, or if the line of action of the force passes through the origin. With the help of above comprehension, choose the most appropriate alternative for each of the following questions: (i) What is the rotational analogue of force? (ii) A body is in rotational motion. Is it necessary that a torque be acting on it? (iii)Why do we prefer to use a wrench of longer arm? OR (iii) Why in hand driven grinding machine, handle is put near the circumference of the stone or wheel?	**4**

S.No.	Question Details-GRAVITATION		Marks
	MCQ		
1	If the radius of the earth is made three times, keeping the mass constant, then the weight of a body on the earth's surface will be as compared to its previous value is		
	a. one third	c. Three times	
	b.one ninth	d. Nine times	
2.	**The gravitational force between two-point masses $m_1$and m_2 at separation *r* is given by $F = k\frac{m_1 m_2}{r^2}$. The constant *k***		**1**
	a. Depends on system of units only	b. Depends on medium between masses only	
	c. Depends on both (a) and (b)	d. Is independent of both (a) and (b)	
3	If density of the earth is doubled keeping its radius constant, then acceleration due to gravity (present value 9.8m/s^2) will be:		
	a. 9.8 m/s^2	b. 2.45 m/s^2	
	c. 4.9 m/s^2	d. 19.6 m/s^2	
4.	Assuming the earth to have a constant density, point out which of the following curves show the variation of acceleration due to gravity from the center of earth to the points far away from the surface of earth		**1**
	a. 	b. 	
	c. 	d. None of the above	
5.	Two stationary particles of masses M_1 and M_2 are at distance d apart. A third particle, lying on the line joining the particles, experiences no resultant gravitational force. The distance of this particle from M_1 is		**1**
	a. $d\left(\frac{\sqrt{M_2}}{\sqrt{M_1}-\sqrt{M_2}}\right)$	b. $d\left(\frac{\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}\right)$	

	c. $d\left(\frac{\sqrt{M_1}}{\sqrt{M_1}-\sqrt{M_2}}\right)$	d. $d\left(\frac{M_1}{M_1+M_2}\right)$	
6.	The earth rotates about the sun in an elliptical orbit. At which point will its velocity be maximum?  		**1**
	a. B	b. C	
	c. A	d. D	
7.	A mass M is split into two parts, m and (M, m), which are then separated by a certain distance. What ratio of m/M maximizes the gravitational force between the two parts		**1**
	a. 1/3	b. 1/2	
	c. ¼	d. 1/5	
8.	If the radius of the earth were to shrink by 1% its mass remaining the same, the acceleration due to gravity on the earth's surface would		**1**
	a. Decrease by 2%	b. Remain unchanged	
	c. Increase by 2%	d. Increase by 1%	
9	A simple pendulum has a time period *T1*when on the earth's surface and *T*2 when taken to a height R above the earth's surface, where R is the radius of the earth. The value of *T*2/*T*1 is		**1**
	a. 1	b. √2	

	c. 4	d. 2	
10.	An artificial satellite moving in a circular orbit around the earth has a total (kinetic + potential) energy *E*0. Its potential energy is		**1**
	a. $-E_0$	b. $1.5E_0$	
	c. $2E_0$	d. E_0	
11.	If the distance between the earth and the sun becomes half its present value, the number of days in a year would have been		**1**
	a. 64.5	b. 129	
	c. 182.5	d. 730	
12	If the earth is at one-fourth of its present distance from the sun, the duration of the year will be		**1**
	a. Half the present year	b. One-eighth the present year	
	c. One-fourth the present year	d. One-sixth the present year	
13.	Assertion: If the radius of the earth is decreased keeping its mass constant, the effective value of g may increase or decrease at the pole. Reason: Value of g on the surface of earth is given by $g = GM/R^2$		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	

14.	Assertion: The square of the period of revolution of a planet is proportional to the cube of the semi-major axis of its elliptical orbit. Reason: Sun's gravitational field is inversely proportional to the square of its distance from the plane		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
15	Assertion : A body becomes massless at the centre of earth. Reason : This follows from g' = g (1 – d/R)		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
16	Assertion : For the planets orbiting around the sun, angular speed, linear speed and K.E. changes with time, but angular momentum remains constant. Reason : No torque is acting on the rotating planet. So its angular momentum is constant.		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
17	Assertion : Gravitational potential is maximum at infinity. Reason : Gravitational potential is the amount of work done to shift a unit mass from infinity to a given point in gravitational attraction force field**.**		**1**
	a. Assertion is correct, reason is correct; reason is a correct explanation for assertion.	b. Assertion is correct, reason is correct; reason is not a correct explanation for assertion	
	c. Assertion is correct, reason is incorrect	d. Assertion is incorrect, reason is correct.	
18.	The linear speed of a planet around the Sun is not constant in its orbit. Comment.		**1**

19.	If Earth be at one half its present distance from the Sun, how many days will be there in a year?	**1**
20.	Moon travelers tie heavy weight at their back before landing on the Moon. Why?	**1**
21.	Why is gravitational potential energy negative?	**1**
22.	What is the work done in bringing a body of mass m from infinity to the surface of Earth of radius R and mass M?	**1**
23.	Two satellites A and B are orbiting around the Earth in circular orbits of the same radius. The mass of A is 16 times that of B. What is the ratio of the period of revolution of B to that of A?	**1**
24.	Does the gravitational force of attraction of the Earth become zero at some height above the surface of Earth? Why?	**1**
25.	Suppose a hole is drilled completely through the Earth along a diameter. Mass and radius of Earth are M and R. What is the force acting on a body of mass m at a distance r from the center of Earth?	**1**
26.	Taking the Moon's orbit around earth to be r and mass of Earth 81 times the mass of the Moon. Find the position of the point from the Earth, where the net gravitational field is zero.	**1**
27	If a man goes from the surface of earth to a height equal to the radius of the earth, then what will be his weight relative to that on the earth? What if he goes equally below the surface of earth?	1
28	At what depth below the earth's surface does the value of g become 50% of its value on the surface?	**2**
29	Why is there no atmosphere on the moon?	**2**
30	A rocket is fired vertically with speed of 5 km / s from the Earth's surface. How far from the earth does the rocket go before returning to the earth? Mass of earth = $6x10^{24}$ kg, radius of earth = 6.4×10^6 m. $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}	**2**
31	Two satellites are at different heights. Which would have greater velocity?	**2**
32	The value of acceleration due to gravity at the moon is 1/6 of the value of g at the surface of the earth and the diameter of the moon is 1/4th of the diameter of the earth. Compare the ratio of the escape velocities.	**2**
33	A body weighs 900N on the surface of earth. How much will it weigh on the surface of a planet whose mass is 1/9 and radius 1/2 that of earth?	**2**
34	A geostationary satellite is orbiting the earth at a height of 6R above the surface of earth. Here R is the radius of the earth. What is the period of another satellite at a height of 2.5 R from the surface of the earth?	**2**
35	Three masses, each equal to M, are placed at the three corners of a square of side a. Calculate the force of attraction on unit mass at the fourth corner.	**2**

36	The radius of a planet is double than that of the earth, but their average densities is same. If the escape velocities at the planet and at the earth are vp and ve respectively, then prove that vp =2ve]	**2**
37	State Kepler's laws of planetary motion. Derive the second law.	**3**
38	An artificial satellite circled around the earth at a distance of 3400 km. Calculate its orbital velocity and period of revolution. Radius of earth = 6400 km and g = 9.8 m/s^2	**3**
39	An earth satellite makes a complete circular orbit in 1.5 hr. Determine the altitude of satellite above the surface of earth. Given: radius of earth = 6370km and g = 9.8 m/s^2 [277.2 km]	**3**
40	State Newton's law of Gravitation. Find the percentage decrease in the weight of the body when taken to a height of 16 km above the surface of the earth. Radius of the earth is 6400km. [5%]	**3**
41	If the earth, supposed to be a uniform sphere contracts slightly so that its radius becomes less by R/n than before, show that the length of the day shortens by 48/n hours.	**3**
42	Two masses, 800 kg and 600 kg are at a distance 0.25 m apart. Find the magnitude of the total force experienced by a body of mass 1 kg placed at a point distance 0.2 m from the 800 kg mass and 0.15 m from the 600 kg mass. [2.22 $x10^{-6}$ N]	**3**
43	If the earth is ¼ of its present distance from the Sun, then what is the duration of the year? [0.125 year]	**3**
44	What is escape velocity? Derive an expression for it .	**5**
45	Derive an expression potential energy of a mass m placed in the gravitational field of another mass M, the distance between the two being r.	**5**
46	Define acceleration due to gravity. Show that the value of acceleration gravity decreases with depth.	**5**
47	Define acceleration due to gravity. Show that the value of acceleration due to gravity decrease with the altitude.	**5**
48	**Case Study : 1** **Read the following paragraph and answer the questions.** A free-falling object is an object that is falling under the sole influence of gravity. A free-falling object has an acceleration of 9.8 m/s/s, downward (on Earth). This numerical value for the acceleration of a free-falling object is such an important value that it is given a special name. It is known as the **acceleration of gravity** - the acceleration for any object moving under the sole influence of gravity. A matter of fact, this quantity known as the acceleration of gravity is such an important quantity that physicists have a special symbol to	**4**

	denote it - the symbol **g**. The numerical value for the acceleration of gravity is most accurately known as 9.8 m/s/s. There are slight variations in this numerical value (to the second decimal place) that are dependent primarily upon on altitude/latitude /depth. (i) At what height will a man's weight become half of his weight on the surface of Earth? (ii) Draw graph showing the variation of acceleration due to gravity with height above the earth surface (iii) The masses of two planets are in the ratio 1**:** 2. Their radii are in the ratio 1: 2. What will be the ratio of the acceleration due to gravity on the planets? OR (iii)A body weighs 900N on the surface of earth. How much will it weigh on the surface of a planet whose mass is 1/9 and radius 1/2 that of earth?	
49	**Case Study : 2** **Read the following paragraph and answer the questions.** Escape velocity is the minimum velocity required to overcome the gravitational potential of a massive body and escape to infinity. Orbital velocity is the velocity with which an object revolves around a massive body. **The relation between escape velocity and orbital velocity are proportional**. The total energy of the satellite is the sum of all energies possessed by the satellite in the orbit around the earth. Total energy of the satellite is the sum of kinetic energy of the satellite and potential energy of the satellite. (i)What is the relation between orbital velocity and escape velocity? (ii)Moon has no atmosphere. Why? (iii) Two satellites of mass m and 9m are orbiting a planet in orbits of radius R. What will be in the ratio of their Time periods? OR (iii) For a satellite moving in an orbit around the earth, what is the ratio of kinetic energy to potential energy?	**4**