JEE MAINS TEST-13 (08-01-2024) (#1345)

Total Marks: 300

Total Duration: 180 minutes

Instructions

1. The question paper consists of **'90'** objective-type questions. There are **'30'** questions each in **Mathematics, Physics and Chemistry** respectively in **2 Sections (A) & (B). Section 'A' contains 20 MCQ (One correct option type) questions and all are mandatory. Section 'B' contains 10 (Numerical value type) questions, only '5' is to be attempted.**

2.The test is of **3** hours duration, and thisTest contains **90** questions.Each question carries **4** marks. For each correct
response, the candidate will get **4** marks. For each incorrect response, **one** mark will be deducted from the total scores. The maximum marks are **300**.

Section: Physics Section - A

Marks per question: 4
20 of 20 question(s) in this section will be shown to examinee
Examinee should answer all 20 question(s) in this section
This section has negative marking for incorrect answer(s). 25% marks will be deducted for every incorrect answer.

Q1 Difficulty Level: Easy

Knowledge Level: K1

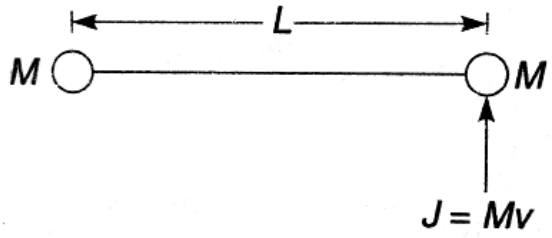
The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied ?

- (●) Length = 50 cm, diameter = 0.5 mm
- ( ) Length = 100 cm, diameter = 1 mm
- ( ) Length = 200 cm, diameter = 2 mm
- ( ) Length = 300 cm, diameter = 3 mm

Q2 Difficulty Level: Easy

Knowledge Level: K1

Consider a body, shown in figure, consisting of two identical balls, each of mass M connected by a light rigid rod. If an impulse J = Mv is imparted to the body at one of its end, what would be its angular velocity?



- (●) v/L
- ( ) 2v/L
- ( ) v/3L
- ( ) v/4L

Q3 **Difficulty Level: Easy**

Knowledge Level: K1

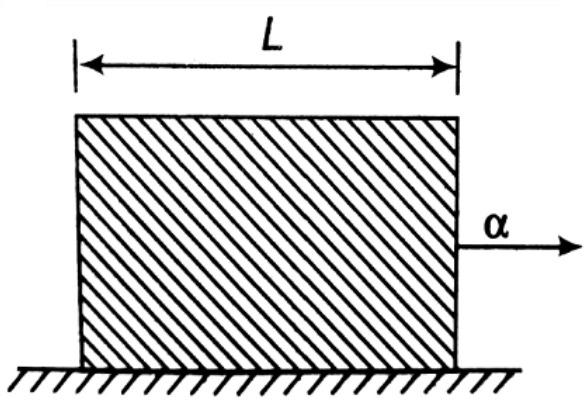
A satellite is reolving in a circular orbit at a height 'h' from the earth's surface (radius of earth R ; h << R). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to : (Neglect the effect of atmosphere).

- ◉ $\sqrt{gR}\left(\sqrt{2}-1\right)$
- ○ $\sqrt{2gR}$
- ○ $\sqrt{gR}$
- ○ $\sqrt{\frac{gR}{2}}$

Q4 **Difficulty Level: Easy**

Knowledge Level: K1

A uniform rod of length L and density ρ is being pulled along a smooth floor with a horizontal acceleration α . (see figure). The magnitude of the stress at the transverse cross-section through the mid-point of the rod is.....



- ○ $2\alpha\rho L$
- ◉ $\frac{\alpha\rho L}{2}$
- ○ $\frac{\alpha\rho L}{3}$
- ○ $\alpha\rho L$

Q5 **Difficulty Level: Easy**

Knowledge Level: K1

A force $\vec{F} = 3x^2y\hat{i} + x^3\hat{j}$ is acting on a mass m = 1kg kept in X-Y plane. If w be the w.d. by the force when mass moves from coordinates (0, 0) to (3, 5) under the action of the force. The value of w will be :-

- (●) 135 J
- ( ) 50 J
- ( ) 100 J
- ( ) 375 J

Q6 **Difficulty Level: Easy**

Knowledge Level: K1

A particle of mass m moving in the x-direction with speed 2v is hit by another particle of mass 2m moving in the y-direction with speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

- ( ) 50%
- (●) 56%
- ( ) 62%
- ( ) 44%

Q7 **Difficulty Level: Easy**

Knowledge Level: K1

A wire of length L and cross-sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, the work done is

- ○ $2\left[\frac{YA}{L}\right]x^2$
- ○ $4\left[\frac{YA}{L}\right]x^2$
- ◉ $\frac{1}{2}\left[\frac{YA}{L}\right]x^2$
- ○ $\left[\frac{YA}{L}\right]x^2$

Q8 **Difficulty Level: Easy**

Knowledge Level: K1

Four particles, each of mass M and equidistant from each other, move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is :

- ○ $\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$
- ◉ $\frac{1}{2}\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$
- ○ $\frac{1}{2}\sqrt{\frac{GM}{R}}$
- ○ $\sqrt{2\sqrt{2}\frac{GM}{R}}$

Q9 **Difficulty Level: Easy**

Knowledge Level: K1

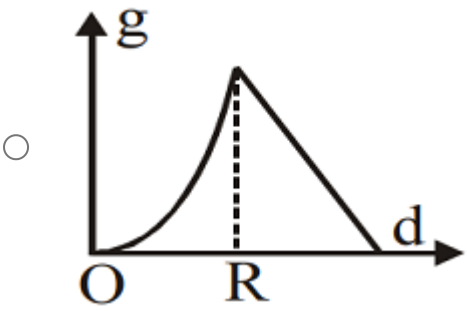
A hoop of radius and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip?

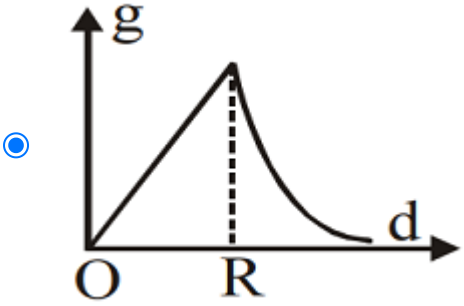
- ◉ $r\omega_0/4$
- ○ $r\omega_0/3$
- ○ $r\omega_0/2$
- ○ $r\omega_0$

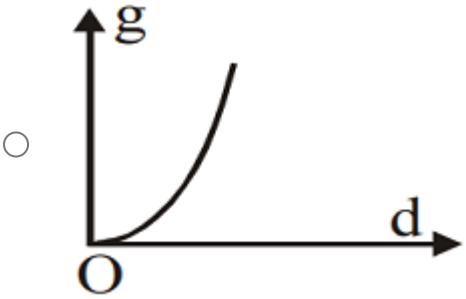
Q10 **Difficulty Level: Easy**

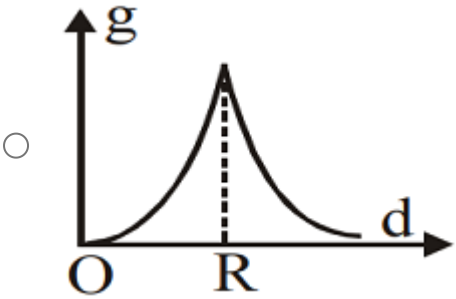
Knowledge Level: K1

The variation of acceleration due to gravity g with distance d from centre of the earth is best represented by (R = Earth's radius) :-





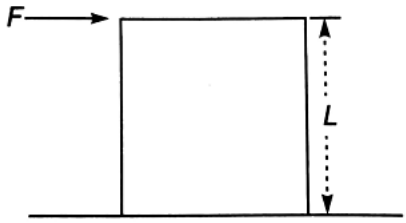




Q11 **Difficulty Level: Easy**

Knowledge Level: K1

A cubical block of side L rests on a rough horizontal surface with coefficient of friction μ. A horizontal force F is applied on the block as shown. If the coefficient of friction is sufficiently high, so that the block does not slide before toppling, the minimum force required to topple the block is



- ○ infinitesimal
- ○ mg/4
- ◉ mg/2
- ○ mg(1-μ)

Q12 **Difficulty Level: Easy**

Knowledge Level: K1

A satellite is moving with a constant speed V in a circular orbit about the earth. An object of mass 'm' is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of its ejection, the kinetic energy of the object is :-

- ○ $\frac{1}{2}mV^2$
- ◉ mV^2
- ○ $\frac{3}{2}mV^2$
- ○ $2mV^2$

Q13 **Difficulty Level: Easy**

Knowledge Level: K1

A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at distance x from A. The normal reaction on B is

- ○ $W\left(\frac{d-x}{d}\right)$
- ○ W
- ◉ $\frac{Wx}{d}$
- ○ $\frac{W}{d}$

Q14 **Difficulty Level: Easy**

Knowledge Level: K1

A smooth sphere A is moving on a frictionless horizontal plane with angular velocity ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision their angular speeds are ω_A and ω_B respectively. Then,

- ○ $\omega_A < \omega_B$
- ◉ $\omega_B = 0$
- ○ $\omega_B = \omega_A$
- ○ $\omega_B = \omega$

Q15 **Difficulty Level: Easy**

Knowledge Level: K1

The mass of a spaceship is 1000 kg. It is to be launched from the earth's surface out into free space. The value of 'g' and 'R' (radius of earth) are 10 m/s^2 and 6400 km respectively. The required energy for this work will be :-

- (●) 6.4×10^{10} Joules
- ( ) 6.4×10^{11} Joules
- ( ) 6.4×10^{8} Joules
- ( ) 6.4×10^{9} Joules

Q16 **Difficulty Level: Easy**

Knowledge Level: K1

Two bodies of masses m and 4m are placed at a distance r. The gravitational potential at a point on the line joining them where the gravitational field is zero is :-

- ( ) $-\frac{6Gm}{r}$
- (●) $-\frac{9Gm}{r}$
- ( ) zero
- ( ) $-\frac{4Gm}{r}$

Q17 **Difficulty Level: Easy**

Knowledge Level: K1

The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where g = the acceleration due to gravity on the surface of the earth) in terms of R, the radius of the earth, is :-

- (●) $\frac{R}{2}$
- ( ) $\sqrt{2}R$
- ( ) $2R$
- ( ) $\frac{R}{\sqrt{2}}$

Q18 **Difficulty Level: Easy**

Knowledge Level: K1

A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small compared to the mass of the earth

- (●) the acceleration of S is always directed towards the centre of the earth
- ( ) the angular momentum of S about the centre of the earth changes in direction, but its magnitude remains constant
- ( ) the total mechanical energy of S varies periodically with time
- ( ) the linear momentum of S remains constant in magnitude

Q19 **Difficulty Level: Easy**

Knowledge Level: K1

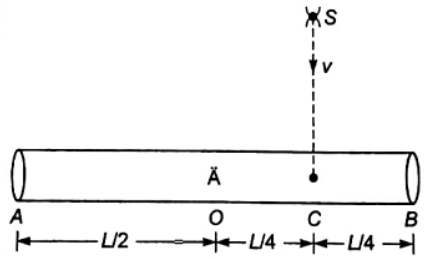
Imagine a light planet revolving around a very massive star in a circular orbit of radius R with a period of revolution T. If the gravitational force of attraction between the planet and the star

- ○ T^2 is proportional to R^2
- ◉ T^2 is proportional to $R^{7/2}$
- ○ T^2 is proportional to $R^{3/2}$
- ○ T^2 is proportional to $R^{3.75}$

Q20 **Difficulty Level: Easy**

Knowledge Level: K1

A homogeneous rod AB of length L and mass M is pivoted at the centre O in such a way that it can rotate freely in the vertical plane (figure). The rod is initially in the horizontal position. An insect S of the same mass M falls vertically with speed v on the point C, midway between the points O and B. Immediately after falling, the insect moves towards the end B such that the rod rotates with a constant angular velocity ω. Angular velocity ω in terms of v and L just after the fall of the insect will be



- $\frac{8v}{7L}$
- $\frac{12v}{9L}$
- $\frac{12v}{7L}$
- $\frac{8v}{15L}$

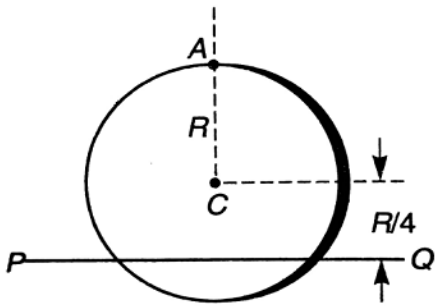
Section: Physics Section - B

Marks per question: 4
10 of 10 question(s) in this section will be shown to examinee
Examinee should answer any 5 question(s) out of the 10 question(s) shown
This section has negative marking for incorrect answer(s). 25% marks will be deducted for every incorrect answer.

Q1 Difficulty Level: Easy

Knowledge Level: K1

A uniform circular disc has radius R = 2 m and mass m = 2kg . A particle, also of mass m, is fixed at a point. A on the edge of the disc as shown in the figure. The disc can rotate freely about a horizontal chord PQ that is at a distance R/4 from the centre C of the disc. The line AC is perpendicular to PQ. Initially the disc is held vertical with the point A at its highest position. It is then allowed to fall, so that it starts rotation about PQ. If v be the linear speed of the particle as it reaches its lowest position. v =_____m/s (Take g = 10m/s^2)



SNo	Blank	Answers
1	Integers	i. 10

Q2 **Difficulty Level: Easy**

Knowledge Level: K1

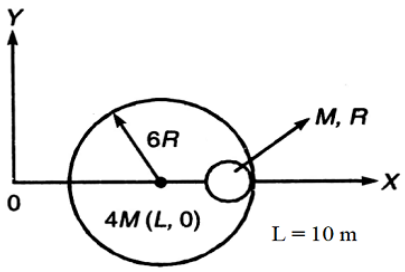
Two rods of different materials having coefficients of thermal expansion α_1, α_2 and Young'smoduli Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2 : 3$ the thermal stresses developed in the two rods are equal provided. Calculate $4Y_1 =$_____ Y_2.

SNo	Blank	Answers
1	Integers	i. 6

Q3 **Difficulty Level: Easy**

Knowledge Level: K1

A small sphere of radius R = 1 m is held against the inner surface of a larger sphere of radius 6R. The masses of large and small spheres are 4M and M(where M = 1kg) respectively. This arrangement is placed on a horizontal table. There is no friction between any surfaces of contact. The small sphere is now released, the x-coordinates of the centre of the larger sphere when the smaller sphere reaches the other extreme position will be _____m.



SNo	Blank	Answers
1	Integers	i. 12

Q4 **Difficulty Level: Easy**

Knowledge Level: K1

One end of a horizontal thick copper wire of length 3L and radius 3R is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is_____.

SNo	Blank	Answers
1	Integers	i. 3

Q5 **Difficulty Level: Easy**

Knowledge Level: K1

If V_0 be the minimum velocity required to project a mass m = 1000kg from the surface of earth to infinity. Calculate $\sqrt{2}V_0$ =_____km/s. (Take R_e = 6400km

SNo	Blank	Answers
1	Integers	i. 16

Q6 **Difficulty Level: Easy**

Knowledge Level: K1

If T_1 be the number of days in a year when the distance between the sun and the earth has been doubled. Calculate $\sqrt{2}T_1$ = _____days

SNo	Blank	Answers
1	Integers	i. 1460

Q7 **Difficulty Level: Easy**

Knowledge Level: K1

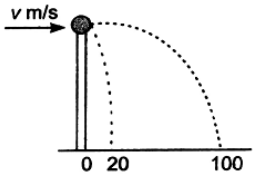
A satellite of mass m = 800 kg revolves around the earth of radius R = 6400km at a height x = 29600 km from its surface. If g is the acceleration due to gravity on the surface of the earth. If V_0 be the orbital speed of the satellite then calculate $\frac{6V_0}{10\sqrt{10}}$ = _____ m/s.

SNo	Blank	Answers
1	Integers	i. 640

Q8 **Difficulty Level: Easy**

Knowledge Level: K1

A ball of mass 0.2 kg rests on a vertical post of height 5 m. A bullet of mass 0.01 kg, travelling with a velocity v m/s in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at a distance of 100 m from the foot of the post. The initial velocity v of the bullet is____ m/s

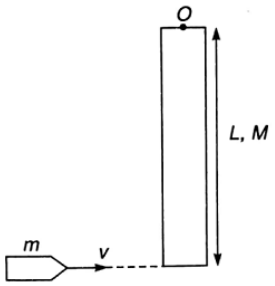


SNo	Blank	Answers
1	Integers	i. 500

Q9 Difficulty Level: Easy

Knowledge Level: K1

A rod of length L = 1m and mass M = 10 kg is hinged at point O. A small bullet of mass m = 1kg hits the rod with velocity $\vec{v} = 26\hat{i}$ m/s shown in the figure. The bullet gets embedded in the rod. If ω be the angular velocity of the system just after impact. ω = _____rad/s



SNo	Blank	Answers
1	Integers	i. 6

Q10 Difficulty Level: Easy

Knowledge Level: K1

A particle is projected vertically upwards from the surface of earth (radius R = 6400km)with a kinetic energy equal to half of the minimum value needed for it to escape. If h be the maximum height to which it rises above the surface of earth . Calculate 2h = _____km.

SNo	Blank	Answers
1	Integers	i. 6400