JEE-MAIN 2025
Physics
Practice Test - 2

Date : **Time : 75 Min.** **Max. Marks : 80**

<u>Marking Scheme :</u>

SCQ - 1 - 3, (4, –1)
MCQ = 4 - 9, (4, –1)
Comprehension = 10 - 18, (4, –1)
Integer = 19 - 20, (4, –1)

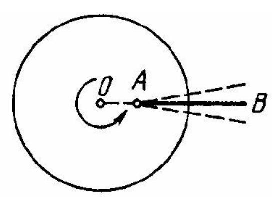
SECTION-1 : (Only One option correct type)

This section contains **3 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

1. Two physical pendulums perform small oscillations about the same horizontal axis with frequencies ω_1 and ω_2. Their moments of inertia relative to the given axis are equal to I_1 and I_2 respectively. In a state of stable equilibrium the pendulums were fastened rigidly together. What will be the frequency of small oscillations of the compound pendulum ?

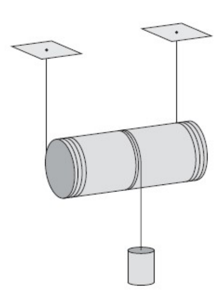
(A) $\omega = \sqrt{\frac{I_1\omega_1^2 + I_1\omega_2^2}{I_1 + I_2}}$ (B) $\omega = \sqrt{\frac{I_1\omega_1 + I_1\omega_2}{I_1 + I_2}}$ (C) $\omega = \sqrt{\omega_1^2 + \omega_2^2}$ (D) $\omega = \sqrt{\omega_1\omega_2}$

2. A smooth horizontal disc rotates about the vertical axis O with a constant angular velocity ω. A thin uniform rod AB of length ℓ performs small oscillations about the vertical axis A fixed to the disc at a distance 'a' from the axis of the disc. Find the frequency ω_0 of these oscillations. Assuming that $\ell << a$.



(A) $\omega_o = \sqrt{\frac{3a\omega^2}{2\ell}}$ (B) $\omega_o = \sqrt{\frac{3a^2\omega^2}{2\ell^2}}$ (C) $\omega_o = \sqrt{\frac{5a^2\omega^2}{2\ell^2}}$ (D) $\omega_o = \sqrt{\frac{a\omega^2}{2\ell}}$

3. A cylindrically symmetric body is attached to two identical cords at points near its ends. The cords are partially wound in the same sense around the cylinder, and their free ends are fastened to points on a ceiling; initially, the cords are vertical and the cylinder is horizontal. A third cord is attached to and wound (in the same sense as the other two cords) around the middle of the cylinder; a heavy weight is tied to the free end of this cord (see figure). (Assuming mass of cylinder and heavy weight are same)



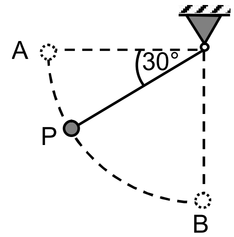
When the system is released from rest, what is the acceleration of the heavy weight?

(A) $\frac{g}{2}$ (B) $\frac{6g}{11}$ (C) $\frac{3g}{11}$ (D) 0

SECTION-2 : (One or more option correct type)

This section contains **6 multiple choice question.** Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** are correct.

4. A simple pendulum is released from rest with its string horizontal. Which of the two arcs, AP and PB as defined in the figure. Which of following options is/are correct ?



(A) In path AP, bob will take time greater than $\sqrt{\frac{\ell}{g}}$.

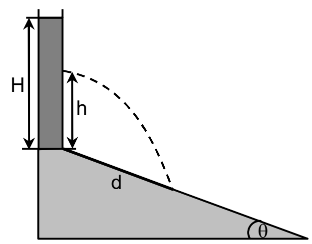
(B) In path AP, bob will take more time than that of in path PB.

(C) In path AP, bob will take less time than that of in path PB.

(D) In path AP, bob will take equal time than that of in path PB.

5. At the top of a long incline that makes an angle θ with the horizontal, there is a cylindrical vessel containing water to a depth H. A hole is to be drilled in the wall of the cylinder, so as to produce a water jet that lands a distance d down the incline. h is made as from the bottom of the vessel should the hole be drilled in order to make d as large as possible?

Assume that velocity of water = $\sqrt{2gx}$



(A) If $\tan\theta < \frac{1}{2}$ then maximum value of d is $d_{max} = \frac{H}{\cos\theta - \sin\theta}$

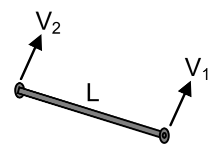
(B) If $\tan\theta < \frac{1}{2}$ then maximum value of d is $d_{max} = \frac{H}{\cos\theta + \sin\theta}$

(C) If $\tan\theta > \frac{1}{2}$ then value of h for d_{max} is 0.

(D) If $\tan\theta < \frac{1}{2}$ then value of h for d_{max} is 0.

6. A uniform rod of mass m and length L is fitted at each end with a frictionless bearing in the form of a freely rotating wheel, for which the rod acts as an axle. The two bearings are identical and have negligible masses compared to that of the rod.

How does the rod move if it is placed on a horizontal rough surface – assuming that the bearings roll on it without slipping – and the two ends of the rod are initially given parallel velocities of v_1 and v_2 in a direction that is perpendicular to the axis of the rod? Assuming $V_1 < V_2$



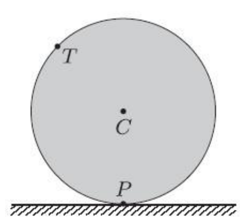
(A) Centre of mass of rod moving on circle of radius $R = \frac{1}{2}\left(\frac{V_1 + V_2}{V_2 - V_1}\right) L$

(B) Centre of mass of rod moving on circle of radius $R = \left(\frac{V_2 - V_1}{V_1 + V_2}\right) L$

(C) Net friction force on system is equal to $f_r = \left(\frac{m\left(V_2^2 - V_1^2\right)}{2L}\right)$

(D) Net friction force on system is equal to $f_r = \left(\frac{m\left(V_1^2 + V_2^2\right)}{L}\right)$

7. A billiard ball, initially at rest on a billiard table, is struck by a cue tip at the point T shown in the figure. The cue lies in the vertical plane containing T, the centre C of the ball and the ball's point of contact P with the table; consequently, so does the line of action of the resulting impulse. The direction of the cue is aligned as order that, after the shot, the ball's subsequent rotational and slipping motions terminate at the same instant, and the ball comes to a halt. Assuming frictionless surface



(A) The direction of cue passing through point C

(B) The direction of cue passing through point P

(C) The angular momentum of system with respect to point P is conserve during impact.

(D) The angular momentum of system with respect to point C is conserve during impact.

8. The spindle of a bicycle chain assembly is mounted horizontally, and a loop of bicycle chain is placed on the toothed wheel, as in the figure. The wheel is then rotated around its axis at a steadily increasing rate until it has achieved a high, but constant, angular velocity. Assuming final velocity of each particle V_0 and mass per unit length is λ.

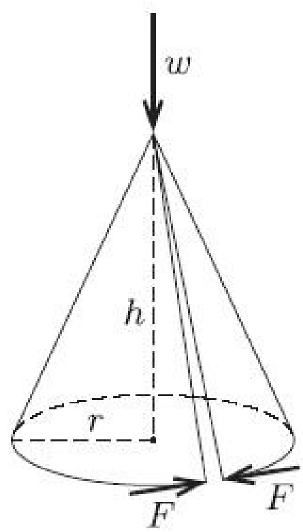
(A) Tension at each point of string is equal to λV^2.

(B) Tension at each point of string is equal to $\frac{1}{2}\lambda V^2$.

(C) Tension at each point of string depends on gravity.

(D) Tension at each point of string does not depend on gravity.

9. A cone with height h and a base circle of radius r is formed from a sector shaped sheet of paper. The sheet is of such a size and shape that its two straight edges almost touch on the sloping surface of the cone. In this state the cone is stress-free.



The cone is placed on a horizontal, frictionless table-top, and loaded at its apex with a vertical force of magnitude w, without collapsing. The splaying of the cone is opposed by a pair of forces of magnitude F acting tangentially at the join in the base circle (see figure). Ignoring any frictional or bending effects in the paper, if the value of F is $\frac{w^{\alpha}}{2\pi}\left(\frac{r^{\beta}}{h^{\gamma}}\right)$ then.

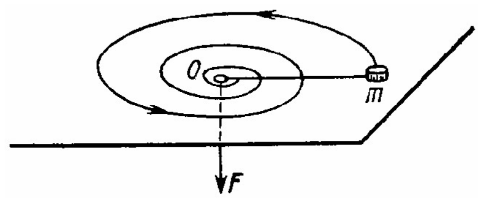
(A) $\alpha = 1$ (B) $\beta = 1$ (C) $\gamma = 1$ (D) $\beta = 2$

SECTION – 3 : (Paragraph Type)

This section contains **3 paragraphs** each describing theory, experiment, data etc**. Nine questions** relate to three paragraphs. Each question of a paragraph has **only one correct answer** among the four choices (A), (B), (C) and (D).

Paragraph for Questions 10 and 12

A small body of mass m tied to a non-stretchable thread moves over a smooth horizontal plane. The other end of the thread is being drawn into a hole O with a constant velocity. If the thread tension as a function of the distance r between the body and the hole is $\frac{mr_o^{\alpha}\omega_o^{\beta}}{r^{\gamma}}$ assuming that at r = r_o the angular velocity of the thread is equal to ω_0.



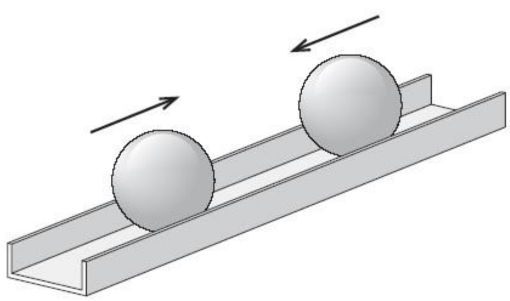
10. Find value of α :
(A) 3 (B) 2 (C) 4 (D) 1

11. Find value of β :
(A) 3 (B) 2 (C) 4 (D) 1

12. Find value of γ :
(A) 3 (B) 2 (C) 4 (D) 1

Paragraph for Question Nos. 13 to 15

Two identical billiard balls of radius 5 cm and each of mass 1Kg, moving with a speed of 3 ms^{-1}, roll, without slipping, towards each other on a horizontal rectangular U-shaped trough that is sufficiently deep that the balls are clear of its base (see figure). The resulting instantaneous collision is perfectly elastic, and, during it, each ball reverses its linear velocity, though their angular velocities are not affected.



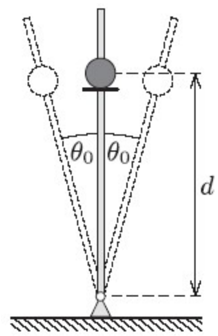
13. How wide does the trough need to be for the balls to collide twice?
(A) $\sqrt{3}$ cm (B) $\sqrt{5}$ cm (C) $\sqrt{15}$ cm (D) $\sqrt{10}$ cm

14. Angular velocity of ball after collision is (Assuming width of trough is least for second collision)
(A) $30\sqrt{10}$ rad/sec (B) $15\sqrt{10}$ rad/sec (C) $10\sqrt{10}$ rad/sec (D) 60 rad/sec

15. Minimum impulse of friction force so that second collision occure is
(A) 3 Kg m/s (B) 2 Kg m/s (C) 1Kg m/s (D) 10 Kg m/s

Paragraph for Questions 16 and 18

A small smooth pearl of mass 'm' is threaded onto a rigid, smooth, vertical rod, which is pivoted at its base. Initially, the pearl rests on a small circular disc that is concentric with the rod, and attached to it at a distance d from the rotational axis. The rod starts executing simple harmonic motion around its original position with small angular amplitude θ_0 (see figure). If average normal reaction in in vertical direction is so that at minimum frequency (ω), the pearl to leave the rod is $\frac{d}{C}\theta_0^{\alpha}\omega^{\beta}m$, where C is constant.



16. Find value of α ?

(A) 2 (B) 3 (C) 4 (D) 5

17. Find value of β ?

(A) 4 (B) 3 (C) 2 (D) 1

18. Minimum frequency of oscillation is required for the pearl to leave the rod?

(A) $\sqrt{\frac{3g}{d\theta_0^2}}$ (B) $\sqrt{\frac{7g}{d\theta_0^2}}$ (C) $\sqrt{\frac{2g}{d\theta_0^2}}$ (D) $\sqrt{\frac{8g}{d\theta_0^2}}$

Integer value correct Type)

This section contains **2 questions**. The answer to each question is a **single digit integer,** ranging from 0 to 9 **OR Two digit integer,** ranging from 00 to 99 (both inclusive)

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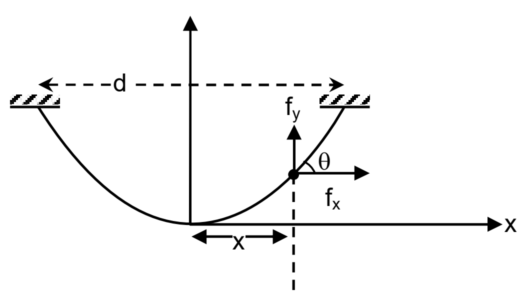
19. If shape does an elastic string of mass 'm' take up when its two ends are fixed to points that are at the same height and separated by a moderate distance is $y = \frac{m^{\alpha}g^{\beta}x^{\gamma}}{2f_x d^z}$. Find α ? (Assuming that θ is very small and f_x and f_y are horizontal and vertical force)



20. In question number 19 find value of γ :

ANSWER KEYS

1.	(A)	**2.**	(A)	**3.**	(D)	**4.**	(AB)	**5.**	(AC)
6.	(AC)	**7.**	(BC)	**8.**	(AD)	**9.**	(ABC)	**10.**	(C)
11.	(B)	**12.**	(A)	**13.**	(C)	**14.**	(A)	**15.**	(A)
16.	(A)	**17.**	(C)	**18.**	(C)	**19.**	1	**20.**	2

SOLUTIONS

Sol.1 Torque on system = $I_1\alpha_1 + I_2\alpha_2$

$$\tau_{ext} = \frac{I_1 d^2\theta}{dt^2} + \frac{I_2 d^2\theta}{dt^2} \qquad \text{....(i)}$$

$$\tau_{ext} = I_1(-\omega_1^2\theta) + I_2(-\omega_2^2\theta) \qquad \text{... (ii)}$$

From (i) & (ii)

$$\frac{I_1 d^2\theta}{dt^2} + \frac{I_2 d^2\theta}{dt^2} = I_1(-\omega_1^2\theta) + I_2(-\omega_2^2\theta)$$

$$\frac{d^2\theta}{dt^2} = -\frac{(I_1\omega_1^2 + I_2\omega_2^2)}{I_1 + I_2}\theta$$

$$\omega = \sqrt{\frac{I_1\omega_1^2 + I_2\omega_2^2}{I_1 + I_2}}$$

Sol.2 $T = 2\pi\sqrt{\dfrac{I}{mg_{eff}\ell_{cm}}}$

$g_{eff} = a\omega^2$

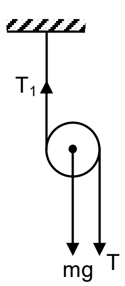
$I = \dfrac{m\ell^2}{3}$

$\ell_{cm} = \dfrac{\ell}{2}$

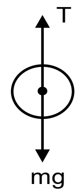
$$T = 2\pi\sqrt{\frac{m\ell^2}{3ma\omega^2\ell/2}} = \frac{2\pi}{\omega_o}$$

$$\omega_o = \sqrt{\frac{3a\omega^2}{2\ell}}$$

Sol.3 $mgR + T2R = \dfrac{3}{2}mR^2\alpha$



$$mg + 2T = \frac{3mR\alpha}{2} \qquad \text{.......(i)}$$



mg – T = m (2Rα) ....(ii)

from (i) and (ii)

$$\frac{mg+2T}{mg-T} = \frac{3}{4}$$

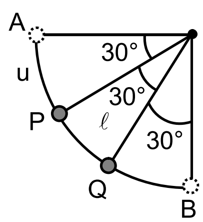
4mg + 8T = 3mg – 3T

$$11T = -mg \Rightarrow T = \frac{-mg}{11} < 0$$

state that block will be in free fall.

Ans. zero

Sol.4



In path PA, vertical acceleration will be less than equal to g. Hence time to cover journey AP.

$$t_{AP} > \sqrt{\frac{2H}{g}} = \sqrt{\frac{2\ell \sin 30}{g}}$$

$$t_{AP} > \sqrt{\frac{2\ell}{2g}} = \sqrt{\frac{\ell}{g}} \quad ....(1)$$

Next divide arch PB in two [arc PQ and QB]

Initial velocity at point P_B $V_P = \sqrt{2g\ell \sin 30^o} = \sqrt{g\ell}$

$$V_Q = \sqrt{2g\ell \sin 60^o} = \sqrt{\sqrt{3}g\ell}$$

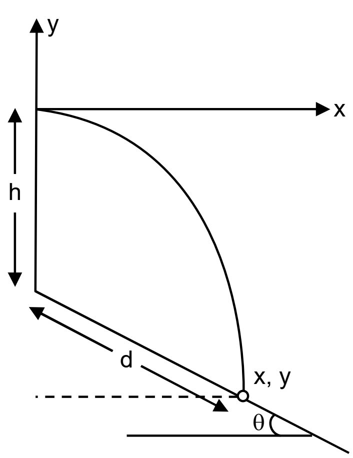
The bob covers $\frac{\ell\pi}{6}$ distance along arcs PQ and QB more rapidly than if it move with constant speed V_P along PQ and V_Q along QB. then

$$t_{PB} < \frac{\ell\pi/6}{V_P} + \frac{\ell\pi/6}{V_Q} \cong 0.92\sqrt{\frac{\pi}{g}}$$

from (1) and (2)

$t_{PB} < t_{AP}$

Sol.5



$$y = x\tan 0^\circ - \frac{gx^2}{2u^2}$$

$$y = -\frac{gx^2}{2u^2} \quad \text{............(i)}$$

Also $u = \sqrt{2h(H-h)}$ ....(ii)

equation of incline plane $y = -x\tan\theta - h$ ....(iii)

from (i), (ii) and (iii) :

$$(-x\tan\theta - h) = \frac{-gx^2}{2(2g)(H-h)}$$

$$x\tan\theta + h = \frac{x^2}{4(H-h)}$$

$$\frac{x^2}{4(H-h)} - x\tan\theta - h = 0$$

$$x^2 + (x\tan\theta - H)\,h + \frac{x^2}{4} - Hx\tan\theta = 0$$

for h real : $D \geq 0$

$$(x\tan\theta - H)^2 - 4\left(\frac{x^2}{4} - xH\tan\theta\right) \geq 0$$

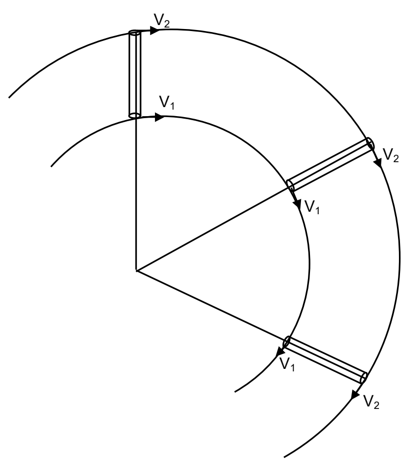
$$(x(\tan\theta + 1) + H)\,(x(\tan\theta - 1) + H) \geq 0$$

$$x(\tan\theta - 1) + H \geq 0$$

$$d\cos\theta = x \leq \frac{H}{1 - \tan\theta}$$

$$d_{max} = \frac{H}{\cos\theta - \sin\theta}$$

Sol.6



$$\omega = \frac{V_2 - V_1}{L}$$

velocity of centre of mass = $\frac{V_1 + V_2}{2}$

Radius centre of mass :

$$v = R\omega$$

$$\frac{v_1 + v_2}{2} = R\frac{v_2 - v_1}{2}$$

$$R = \left(\frac{v_1 + v_2}{v_2 - v_1}\right)\frac{L}{2}$$

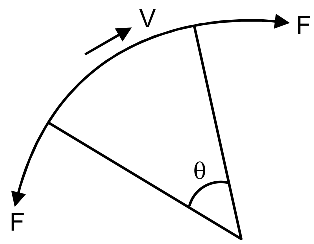
Net friction force on rod :

$$fr = mR\omega^2 = m\left(\frac{v_1 + v_2}{v_2 - v_1}\right)\frac{L}{2}\left(\frac{v_2 - v_1}{L}\right)^2$$

fr = $\frac{m(v_2 - v_1)(v_1 + v_2)}{2L} = \frac{m(v_2^2 - v_1^2)}{2L}$

Sol.7 Torque about point P is 0.

Sol.8



$2F \sin\theta/2 = (\lambda R\theta)\frac{v^2}{R}$

$F = \lambda v^2$ = constant

It does not depend on earth gravity.

Sol.9 When height is decreased by dh then radius is increased by dr.

Using work energy theorem :

$wdh - F2\pi dr = 0$

$F = \frac{w}{2\pi}\left(\frac{dh}{dr}\right)$ ……(1)

Also slant edge of cylinder will be constant.

$\ell^2 = h^2 + r^2$

differentiate w.r.t.r :

$0 = 2hdh + 2rdr$

$\frac{dh}{dr} = -\frac{r}{h}$

Put in (1) : $F = -\frac{w}{2\pi}\left(\frac{r}{h}\right)$

Sol. (10 to 12)

Where r = distance between particle and origin then using constraint equations :

$V = \frac{dr}{dt}$ = const.

$\frac{d^2r}{dt^2} = 0$

Acceleration of particle = $r\omega^2 - \frac{d^2r}{dt^2}$ (toward centre)

$a = r\omega^2$

$F = ma = mr\omega^2 = T$

$T = mr\omega^2$ ….(1)

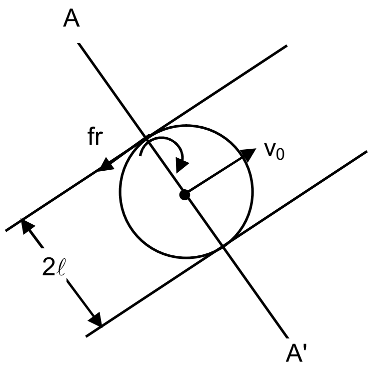
and $I\omega$ = const.

$mr_o^2\omega_o = mr^2\omega \Rightarrow$ $\omega = \frac{r_o^2\omega_o}{r^2}$

$T = \frac{mr_o^4\omega_o^2}{r^3}$

Sol. (13 to 15)

Height of centre of ball from line AA' :



$r = \sqrt{R^2 - \ell^2}$

velocity of centre of ball :

$v_0 = r\omega_0 = \sqrt{R^2 - \ell^2}\,\omega_0$ ......(1)

After collision velocity will be exchange and friction want to decrease velocity as well as angular velocity. For second collision : (ball should move in back word direction)

$F\Delta t = mV_0$ ....(1)

$Fr\Delta t = I\omega_0 = \frac{2}{5}\, mR^2\omega_0$

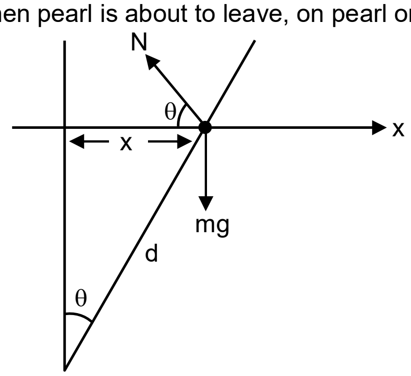
$mv_0 r = \frac{2}{5} mR^2 \frac{v_0}{r}$

$5r^2 = 2R^2 \Rightarrow 5\,(R^2 - \ell^2) = 2R^2$

$\ell = \sqrt{\frac{3}{5}}R$

Sol. **(16 to 18)**

When pearl is about to leave, on pearl only N and mg will be acted.



Since θ is very small :

$x = d\sin\theta = d\theta \cong d\theta_0 \sin\omega t$

$a_x = -d\theta_0\omega^2 \sin\omega t = \frac{N\cos\theta}{m}$

$N \cong -d\,\theta_0\omega^2 m \sin\omega t$

vertical componenet of N :

$N_y = N\sin\theta$

$N_y = -d\theta_0\omega^2 m \sin\omega t \sin\theta$

$N_y \cong -d\theta_0^2\omega^2 m\ \sin^2\omega t$

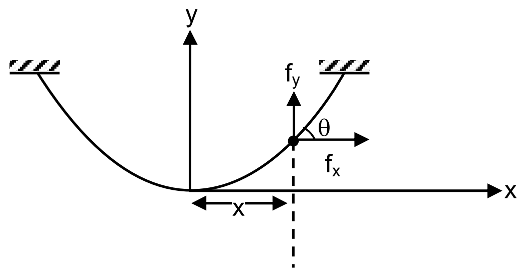
$<N_y> = -\frac{d}{2}\theta_0^2\omega^2 m$

For pearl leave the rod :

$\frac{d}{2}\theta_0^2\omega^2 m > mg$

$\omega > \sqrt{\frac{2g}{d\theta_0^2}}$

Sol.19 x- component of tension of force on spring is always constant because any arbitrary chosen piece of it does not acceleration in horizontal direction.



Condition for vertical equilibrium :

$$2F_y = \left(\frac{m}{d}\right)2xg$$

$$\frac{F_y}{F_x} = \frac{xmg}{dF_x}$$

since tension is always in tangent direction then

$$\frac{dy}{dx} = \frac{xmg}{F_x d}$$

integration :

$$y = \frac{mgx^2}{2f_x d} + C \text{ ....(i)}$$

from co-ordinate system :

C = 0

$$y = \frac{mgx^2}{2F_x d} \text{ ......(ii)}$$

$$y = \frac{m^{\alpha} g^{\beta} x^{\gamma}}{2F_x d^z}$$

$\alpha = 1$; $\beta = 1$; $\gamma = 2$; $z = 1$