JEE-MAIN 2025
Physics
Practice Test - 9

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

Submit (E) : 11-07-2016 (RKH Sir)
Final (E) : 14-07-2016 (RKH Sir)
Send to print (12-07-2016) : (RKH Sir) 4:45
Corrections :- 14-07-16_(RKH Sir)_Time : 11 : 22

Marking Scheme :

SCQ - 1 - 3, (4, –1)

MCQ = 4 - 8, (4, –1)

Comprehension = 09 - 17, (4, –1)

Integer = 18 - 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. A sphere of mass m is moving with a velocity $4\hat{i}+3\hat{j}-5\hat{k}$ when it hits a smooth wall and rebounds with velocity $2\hat{i}+2\hat{j}+3\hat{k}$. Find the coefficient of restitution between the sphere and the wall.

(A) $\frac{6}{15}$ (B*) $\frac{6}{17}$ (C) $\frac{5}{19}$ (D) $\frac{7}{19}$

Sol. Change in momentum = m($-2\hat{i}-\hat{j}+8\hat{k}$).

Let the angle which the sphere makes with the normal to the wall initially be (θ) and the angel which it makes afterwards be (α)

Then impulse is along the normal then equation of e :

e = $\frac{v\cos(\alpha)}{u\cos(\theta)}$ ....(i)

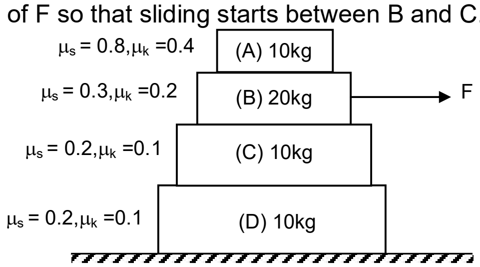
where 'u' and 'v' are the initial and final velocities respectively

$u\cos(\theta)$ = $\vec{u}$.(unit vector angle impulse) = $\frac{\left(4\hat{i}+3\hat{j}-5\hat{k}\right).\left(-2\hat{i}-\hat{j}+8\hat{k}\right)m}{\sqrt{69}} = \frac{-51m}{\sqrt{69}}$

Similarly v cos(α) = $\frac{-18m}{\sqrt{69}}$

From equation (i), e = $\frac{6}{17}$

2. Find the minimum value of F so that sliding starts between B and C.



(A*) 240N (B) 90 N (C) 100 N (D) 300 N

Sol. First sliding will be between C and D while second sliding will be between B and C hence acceleration of B just before second sliding will be 5 m/s^2 and at this acceleration force F will be 240N.

Force equation on system of A + B + C

F – 40 = 40a .... (i)

Force equation on C
90 – 40 = 10a .... (ii)
From (i) and (ii) F = 240 N

3. A brick is given an initial speed of 5ft/s up an inclined plane at an angle of 30° from the horizontal . The coefficient of friction is $\mu = \sqrt{3}/12$. After 0.5s, how far is the brick from its original position ? You may take g = 32ft/s^2.

(A*) 1/4 ft (B) 5/8ft (C) 3/8ft (D) 1ft

Ans. **(A)**

Sol. Acceleration in upward journey (a) = g sin30° + μgcos30° = $\frac{5g}{8} = 20 m/s^2$

Acceleration in downward journey (a) = g sin30° – μgcos30° = $\frac{3g}{8} = 12 m/s^2$

Motion of upward Journey :
Time of upward Journey :
$0 = 5 - 20t_1$

$t_1 = \frac{5}{20}$

Distance travelled in upward journey $0^2 = 5^2 - 2(20)\, x_1$

$x_1 = \frac{5}{8}$ft

Motion in downward journey :

Time of downward journey : $t_2 = \frac{5}{10} - \frac{5}{20} = \frac{5}{20}$

Distance travelled in downward journey $x_2 = \frac{1}{2} 12 \times \frac{5}{20} \times \frac{5}{20} = \frac{3}{8}$

$\Delta x = x_1 - x_2 = \frac{1}{4}$ft

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

This section contains **5 multiple choice question.** Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** are correct.

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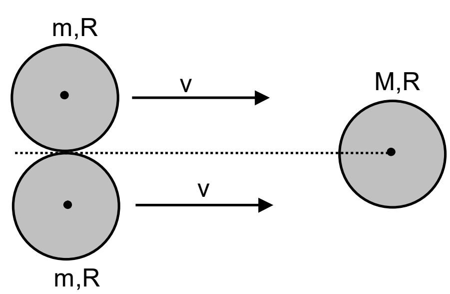
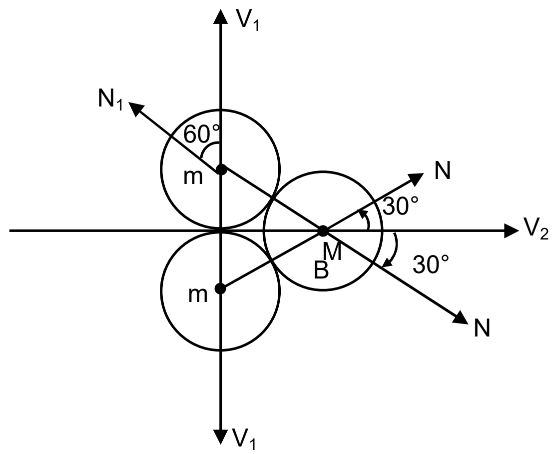
4. There is a disc of mass M and of radius R is at rest at a point on the perpendicular bisector of the line segment joining the centres of mass of the two moving discs. The two moving discs collides totally elastically with the third one, which is at rest .There is no friction between the rims of the discs. If ratio of M/m is 3. Then which of following option(s) is/are correct ?



(A*) After the collision the two discs of mass m move perpendicularly to their initial velocity.
(B) After the collision the two discs of mass m move at 45° to their initial velocity.
(C*) After the collision velocity of block mass m is $\frac{V}{\sqrt{3}}$
(D*) After the collision velocity of block mass M is $\frac{2V}{3}$

Sol.



Momentum conservation in x-direction
$2mv = mV_2$

$V_2 = \frac{2mv}{M}$ ....(1)

equation of e :
$v\cos30° = V_2 \cos30° + V_1 \cos60°$

$v\sqrt{3} = v_2\sqrt{3} + v_1$ ....(2)

equation of implus on (A) :
$N_1 \cos60°\ dt = mv_1$
$N_1 \sin60°\ dt = mv$
dividing two

$\tan60° = \frac{v}{v_1}$

$v_1 = \frac{v}{\tan 60°}$ ....(3)

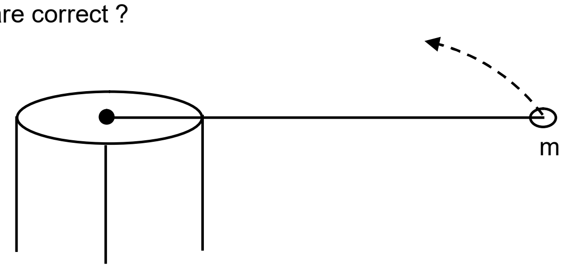
from (3)

$V\sqrt{3} = \frac{2mV}{m}\sqrt{3} + \frac{v}{\sqrt{3}}$

$\frac{2}{\sqrt{3}} = \sqrt{3} - \frac{1}{\sqrt{3}} = \frac{2m}{M}\sqrt{3}$

M/m = 3 Ans

5. The string wraps around the outside of the post. Ignore gravity. Until the ball hits the post, which of following option(s) is/are correct ?

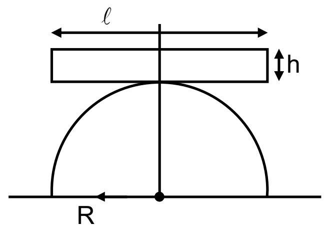


(A*) The energy of particle is increasing until ball hits the post.
(B*) The angular momentum of particle with respect to centre is constant.
(C) Both the energy of the ball and the angular momentum about the centre of the post, change.
(D*) Velocity particle makes acute angle with tension direction on particle in free body diagram.

Ans. **(ABD)**

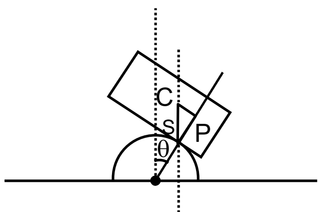
Sol. Since torque of tension force about centre of post is zero, angular momentum will be conserved and since person pulling the string is working on particle, its energy will be increasing.
If u see carefully u will find that particle has two component of velocity, one along perpendicular to string and one along direction of centre of post and hence tension does work on particle.

6. On top of a cylinder with a horizontal axis, a plank is placed, whose length is ℓ and thickness h. For which radius R of the cylinder the horizontal position of plank will be stable equilibrium.

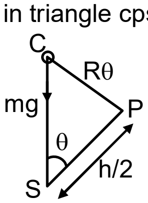


(A) $\frac{h}{3}$ (B) $\frac{h}{4}$ (C*) $\frac{2h}{3}$ (D*) $\frac{3h}{4}$

Sol.



in triangle cps :



For stable equilibrium mg should be in left of vertical line CS. At critical condition, it will be passing through S. Then,

$$\tan\theta = \frac{R\theta}{h/2}$$

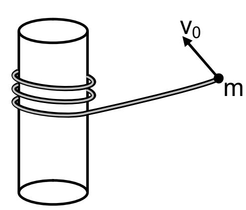
Since θ is very small :

$$\theta = \frac{R\theta}{h/2} \Rightarrow R = \frac{h}{2}$$

If R will be more than length CP = Rθ will be more hence equilibrium will be stable then R > $\frac{h}{2}$

7. A ball of mass m is attached to a part of radius R by a string. Initially it is a distance r_0 from the centre of post and it is moving tangentially with speed v_0. The string wraps around the outside of post. Ignore gravity until the ball hits the post.

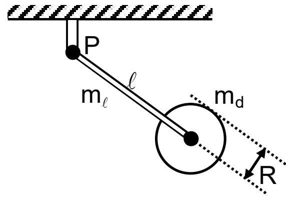
[\\server-1\Session 2015-16\TEST PAPERS\OTHER\TOPPERS TEST MATERIAL\1. TPT_(IA Batch)\Physics\9. 16-10-15_(TPT-9)_(IA Star)\16-10-15_(TPT-9_(IA Star)_(RKH Sir)]



(A*) Energy of the ball is constant.
(B*) Angular momentum of ball about the centre of post, change
(C) Energy of ball changes because tension is not perpendicular to velocity of ball.
(D) Angular momentum of ball about centre of post will be constant.

Sol. Torque of tension about centre of post is not zero. Since point of application of tension on post is not moving, energy will be constant.

8. A physical pendulum consists of a disc of radius R and mass m_d fixed at the end of rod of mass m_ℓ and length ℓ.



(A) Acceleration of each particle of disc must be same and moment of inertia of system about pivot point P is $\frac{1}{3}m_\ell \ell^2 + \frac{1}{2}m_d R^2 + m_d \ell^2$

(B*) If disc is mounted on rod by frictionless bearing then acceleration of each particle on disc must be same and equal to that of centre of disc.

(C) If bearing of rod and disc is frictionless moment of inertia about pivot is $\frac{1}{3}m_\ell \ell^2 + m_d \ell^2$

(D*) Torque of weight about pivot point are same whatever bearing of rod and disc is frictionless or not.

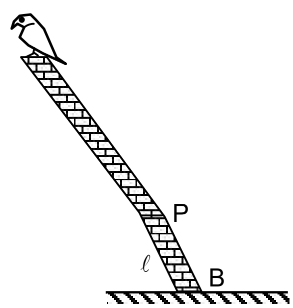
SECTION – 3 : (Paragraph Type)

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 09 and 11

Falling Chimney

A tall, slender, cylindrical brick chimney of height L is slightly perturbed from its vertical equilibrium position so that it topples over, rotating rigidly around its base B until it breaks at point P. Assume that the chimney breaks because the torque is too great and the chimney bends and snaps.



9. Most likely value for the distance ℓ of P from B is :

(A*) $\frac{L}{3}$ (B) $\frac{2L}{3}$ (C) $\frac{L}{2}$ (D) $\frac{L}{4}$

Ans. **(A)**

10. Angle from horizontal when net accleration each particle becomes vertical ?

(A) $\theta = \sin^{-1}\left(\frac{1}{3}\right)$ (B*) $\theta = \sin^{-1}\left(\frac{2}{3}\right)$ (C) $\theta = \sin^{-1}\left(\frac{1}{2}\right)$ (D) $\theta = \sin^{-1}\left(\frac{2}{5}\right)$

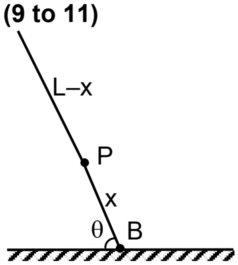
Ans. **(B)**

11. Acceleration of top point of chimney just after break ? Assuming acceleration due to gravity is g.

(A) $\frac{g}{2}m/s^2$ (B) $\frac{g}{3}m/s^2$ (C*) g m/s^2 (D) $\frac{g}{4}m/s^2$

Ans. **(C)**

Sol. **(9 to 11)**



First calculate the motion of the entire chimney of mass m by considering the torque τ about its base B (See Figure)

$$\tau = -mg\frac{L}{2}\cos\theta$$

The moment of inertia bout the base is $I = \left(\frac{1}{3}\right)mL^2$. The equation of motion for θ is found from

$$\tau = I\alpha$$

$$\alpha = -\frac{3}{2}\frac{g}{L}\cos\theta \qquad \text{................. (i)}$$

The piece of the chimney above the point P rotates in response to the torque τ_{cm} produced by its center of mass about P given by

$$\tau_{cm} = -\frac{m(L-x)}{L}g\frac{(L-x)}{2}\cos\theta$$

and the torque $\tau(x)$ produced by the rest of the chimney attached below P, "trying" to convince the piece to rotate at α.

$$\tau(x) - \frac{m(L-x)}{L}g\frac{(L-x)}{2}\cos\theta = \frac{1}{3}\frac{m(L-x)}{L}(L-x)^2\alpha \qquad \text{................. (ii)}$$

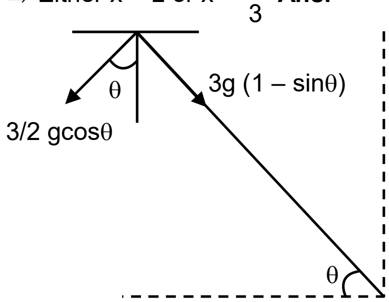
Find $\tau(x)$ by substituting for $\cos\theta$ from (i) :

$$\tau(x) = \frac{1}{3}\frac{m}{L}(L-x)^3\alpha - \frac{m}{3}(L-x)^2\alpha$$

Chimney will be break when $\tau(x)$ will be maximum.

$$\frac{d\tau(x)}{dx} = 0 \ ; \ -\frac{m}{L}(L-x)^2\alpha + \frac{2m}{3}(L-x)\alpha = 0$$

$\Rightarrow$ Either x = L or x = $\frac{L}{3}$ **Ans.**



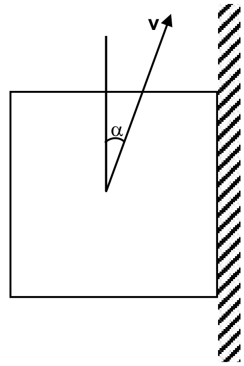
$\Rightarrow \frac{3g}{2}\cos\theta \sin\theta = 3g(1 - \sin\theta)\cos\theta$

$\sin\theta = \frac{2}{3}$

Paragraph for Questions 12 and 14

Cube Bouncing off wall

An cube sliding without friction along a horizontal floor hits a vertical wall with one of its faces parallel to the wall. The coefficient of friction between the wall and the cube is μ = 1. The angle between the direction of the velocity v of the cube and the wall is α = 37°as shown in figure. Assuming coefficient of restitution e = $\frac{1}{2}$.



12. Speed of cube just after collision ?

(A*) $\frac{3V}{10}$ (B) $\frac{V}{10}$ (C) $\frac{V}{5}$ (D) $\frac{V}{15}$

Ans. (A)

13. Angle between the direction of the velocity v of the cube and the wall after collision ?

(A) $\tan^{-1}\left(\frac{3}{2}\right)$ (B) 45° (C) 90° (D) 30°

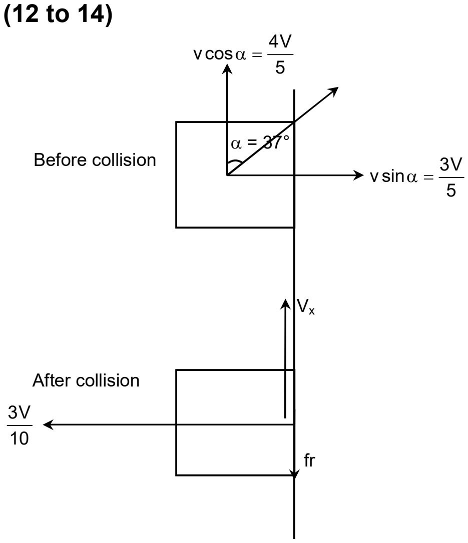
Ans. (C)

14. Impulse of friction force in collisions ?

(A*) $\frac{4mv}{5}$ (B) $\frac{3mv}{5}$ (C) $\frac{7mv}{5}$ (D) $\frac{mv}{5}$

Ans. (A)

Sol. (12 to 14)



$$Ndt = \frac{3mv}{10} + \frac{m3v}{5} = \frac{9mv}{10}$$

Maximum possible impulse of friction = $\mu Ndt = \frac{\mu 9mv}{10} = \frac{9mv}{10}$

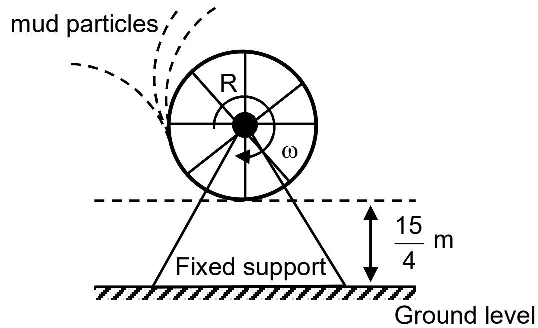
But to stop slipping, required impulse in parallel to wall = $m\left(\frac{4v}{5}\right) = \frac{8mv}{10} < \frac{9mv}{10}$

Hence velocity parallel to wall will be zero.

Paragraph for Questions 15 and 17

Mud from Tire

A tire of cycle is stuck in the mud. A person is rotating cycle tire with angular speed of ω as shown in figure. Splashes mud from the rim of tire of radius R are spinning at a speed $v^2 > gR$. Neglecting the resistance of the air. (Assuming R = 5 m and ω = 2 rad/s)



15. Maximum height up to which, mud particle can go ?

(A) 20 m (B) $\frac{65}{4}$ m (C*) 15 m (D) $\frac{55}{4}$ m

Ans. (C)

16. Angle made by mud particle from horizontal for maximum height from ground level, which is calculated in questions number 15 :

(A) 45° (B*) 30° (C) 60° (D) 53°

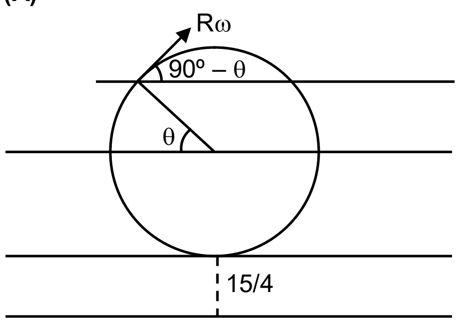
Ans. (B)

17. Velocity of mud particle at maximum height from ground, which is calculated in questions number 15.

(A*) 5 m/s (B) 4 m/s (C) 10 m/s (D) $5\sqrt{3}$ m/s

Ans. (A)

Sol.



$$H = R + R\sin\theta + \frac{(R\omega)^2 \sin^2(90-\theta)}{2g} + \frac{15}{4}$$

$$= R + R\sin\theta + \frac{R^2\omega^2\cos^2\theta}{2g} + \frac{15}{4}$$

For maximum value of H

$$\frac{dH}{d\theta} = 0 = 0 + R\cos\theta - \frac{R^2\omega^2}{2g} 2\cos\theta\sin\theta$$

$$R\cos\theta = \frac{R^2\omega^2\cos\theta\sin\theta}{g}$$

$$\sin\theta = \frac{g}{R\omega^2}$$

R = 5

ω = 2

$$H = 5 + \frac{5}{2} + \frac{5^2(4)\cos^2 30}{2(10)} + \frac{15}{4}$$

$$= 5 + \frac{5}{2} + 5 \times \frac{3}{4} + \frac{15}{4}$$

$$= 5 + \frac{5\times 2}{2\times 2} + \frac{15}{4} + \frac{15}{4} = 5 + \frac{25}{4} + \frac{15}{4} = \frac{45}{4} + \frac{15}{4} = 15$$

SECTION-4 : (Integer value correct Type)

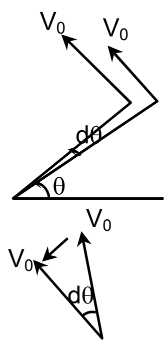
This section contains **3 questions**. The answer to each question is a **single digit integer,** ranging from 0 to 9 (both inclusive)

18. A spaceship of mass m_0 moves in the absence of external forces with a constant velocity v_0. To change the motion direction, a jet engine is switched on. It starts ejecting a gas jet with velocity u which is constant relative to the spaceship and directed at right angles to the spaceship motion. The engine is shut down when the mass of the spaceship decreases to m. Through what angle α (in radian) did the motion direction of the spaceship deviate due to the jet engine operation ?

Assuming $m = \frac{m_0}{e}$; u = 50 m/s ; v_0 = 10 m/s.

Ans. 5

Sol.



Change in velocity in dt time : $dV = 2V_0 \sin\left(\frac{d\theta}{2}\right)$

$$dV = V_0\, d\theta$$

Also using impulse and momentum theorem :

$$\left(v_r \frac{dm}{dt}\right)dt = mdV$$

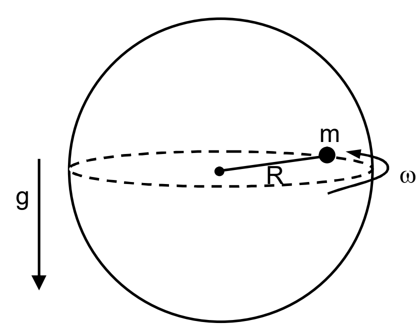
$$udm = mV_0\, d\theta \Rightarrow u\int_m^{m_0} \frac{dm}{m} = v_0 \int_0^{\theta} d\theta$$

$$\theta = \frac{u}{v_0}\ell n\left(\frac{m_0}{m}\right)$$

Put the values : $\theta = \frac{50}{10}\ell ne = 5\text{radian}$

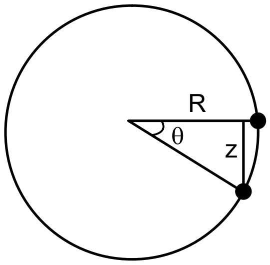
19. **Fast particle in Bowl**

A particle constrained to move on a smooth spherical surface of radius R is projectred horizontally from a point at the level of the centre so that its angular velocity relative to the axis is ω = 2rad/s. (See in the figure). If $\omega^2R >> g$, find maximum depth z below the level of the centre is approximately.



Ans. 5

Sol. $z = \frac{2g}{\omega^2} = 5$



Using AMC :

$m(R\omega)R = mVR\cos\theta$ ....(i)

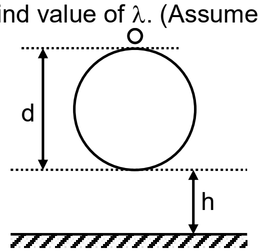
Using energy

$\frac{1}{2}m(R\omega)^2 + mgz = \frac{1}{2}mV^2$ ....(ii)

After using bionomial expansion

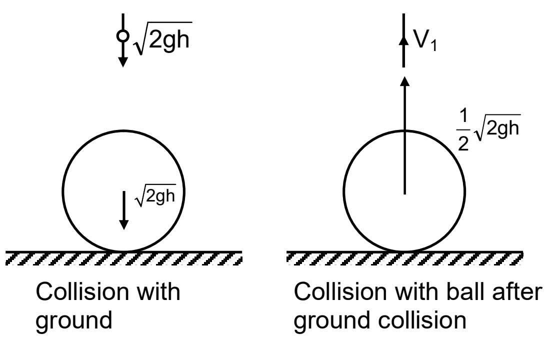
$z = \frac{2g}{\omega^2}$

20. A tennis ball (small) mass m_2 sits on top of basket ball with (larger) mass m_1. The bottom of the basket ball is a height h above ground and bottom of the tennis ball is a height h + d above the ground. The balls are dropped. If height from ground does the tennis ball bounce is $\left(\frac{2\lambda}{16}h\right)+d$? Assume coefficient of restitution for all collision is 1/2. Find value of λ. (Assume $m_1 >> m_2$)



Ans. 5

Sol.



Equation of e :

$\frac{1}{2}\left(\sqrt{2gh}+\frac{1}{2}\sqrt{2gh}\right) = V_1 - \frac{1}{2}\sqrt{2gh}$

$V_1 = \frac{5}{4}\sqrt{2gh}$ ......(1)

Using $V^2 = V_1^2 - 2gh' \Rightarrow 0^2 = \frac{25}{16}2gh - 2gh' \Rightarrow h' = \frac{25}{16}h$