RACE # 21 — VECTOR MULTIPLICATION (DOT PRODUCT) — PHYSICS

1. If the vectors $4\hat{i}+\hat{j}-3\hat{k}$ and $2m\hat{i}+6m\hat{j}+\hat{k}$ are perpendicular to each other, then the value of m is

(A) $\frac{3}{14}$ (B) $-\frac{1}{8}$ (C) $-\frac{2}{3}$ (D) 12

2. Work done by a constant force $\vec{s}$ for displacement $\vec{F}$ is given by $W=\vec{F}\cdot\vec{s}$. What is the work done by a force $\vec{F}=\left(4\hat{i}+2\hat{j}-6\hat{k}\right)$ N when its point of application gets displaced by $\left(\hat{i}-\hat{j}-3\hat{k}\right)$m ?

(A) 18J (B) 20J (C) 30J (D) 24J

3. The value of projection of $\left(3\hat{i}-2\hat{j}+6\hat{k}\right)$ along $\left(2\hat{i}+3\hat{j}-\hat{k}\right)$ is

(A) $-\frac{6}{7}$ (B) $-\frac{6}{\sqrt{14}}$ (C) $-\frac{6}{14}$ (D) None of these

4. The velocity of a particle is $\vec{v}=3\hat{i}+\hat{j}+\hat{k}$. The component of the velocity of the particle parallel to vector $\vec{a}=3\hat{i}+3\hat{j}-3\hat{k}$ is :-

(A) $\hat{i}+\hat{j}-\hat{k}$ (B) $3\hat{i}+3\hat{j}+3\hat{k}$ (C) $\hat{i}+\hat{j}+\hat{k}$ (D) $6\hat{i}+2\hat{j}-2\hat{k}$

5. Vector $\vec{A}$; makes equal angles with *X*, *Y* and *Z* axis. Its vector component on *X*-*Y* plane is

(A) $\frac{A}{3}\left(\hat{i}+\hat{j}\right)$ (B) $\frac{A}{\sqrt{2}}\left(\hat{i}+\hat{j}\right)$ (C) $\frac{A}{6}\left(\hat{i}+\hat{j}\right)$ (D) $\frac{A}{\sqrt{3}}\left(\hat{i}+\hat{j}\right)$

6. Two vectors $\vec{R}=4\hat{i}+C\hat{j}+2\hat{k}$ and $\vec{S}=2\hat{i}+\hat{j}+\hat{k}$ will be parallel if

(A) C = 0 (B) C = 1 (C) C = 2 (D) C = 4

7. The angle between two vectors $\vec{R}=-\hat{i}+\frac{1}{3}\hat{j}+\hat{k}$ and $\vec{S}=x\hat{i}+3\hat{j}+(x-1)\hat{k}$

(A) Is obtuse angle (B) Is acute angle

(C) Is lies between 60° and 120° (D) Depends on x

8. The angle between $(\hat{i}+\hat{j}+\hat{k})$ & $(2\hat{i}+2\hat{j}-2\hat{k})$ is

(A) $\cos^{-1}\frac{1}{3}$ (B) $\cos^{-1}\frac{1}{\sqrt{3}}$ (C) $\sin^{-1}\frac{1}{3}$ (D) None of these

Paragraph for Question no. 9 to 11

In a particular physical situation, a floor is taken as *x*-*y* plane and upward vertical as *z*-direction. At a moment when a force of $\left(6\hat{i}-8\hat{j}+10\hat{k}\right)$N is applied on the block, the block was moving with velocity $\left(3\hat{i}+4\hat{j}\right)$ m/s.

9. Angle made by velocity vector with positive *x*-axis is

(A) 30° (B) 37° (C) 45° (D) 53°

10. Magnitude of component of force along floor is

(A) 6 N (B) 8 N (C) 10 N (D) $10\sqrt{2}$ N

11. Angle between velocity vector and vertical component of force is

(A) 45° (B) 53° (C) 60° (D) 90°

12. When $\vec{A}\cdot\vec{B}=-|\vec{A}||\vec{B}|$, then :-

(A) $\vec{A}$ and $\vec{B}$ are perpendicular to each other

(B) $\vec{A}$ and $\vec{B}$ act in the same direction

(C) $\vec{A}$ and $\vec{B}$ act in the opposite direction

(D) $\vec{A}$ and $\vec{B}$ can act in any direction

13. If $\hat{a},\hat{b},\hat{c}$ are three unit vectors such that their sum is 0, then $\hat{a}.\hat{b}+\hat{b}.\hat{c}+\hat{c}.\hat{a}$ is equal to

(A) –1 (B) 3 (C) 0 (D) $-\frac{3}{2}$

14. Choose the **CORRECT** option(s) :-

(A) $\vec{a}=9\hat{i}-10\hat{j}+7\hat{k}$ and $\vec{b}=5\hat{i}+\frac{9}{2}\hat{j}$ are perpendicular vectors

(B) $|i - j| = |i + j| = \sqrt{\frac{2}{3}}\left|\hat{i}-\hat{j}+\hat{k}\right|$

(C) $\frac{\left|\hat{i}+\hat{j}+\hat{k}\right|}{\sqrt{3}}$ and $\frac{\left|\hat{i}-\hat{j}-\hat{k}\right|}{\sqrt{3}}$ are unit vectors

(D) If $\vec{P}$ is non zero vector, its component along x-axis may be zero

1. Work done by the gravitational force when a book is raised vertically up keeping it on the hand is:

(A) positive (B) negative (C) zero (D) can not be determined

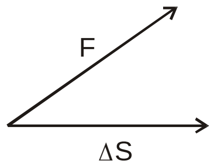
2. Work done by the gravitational force when a book is taken vertically down keeping it on the hand is:

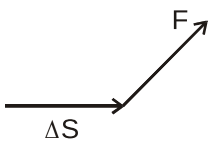
(A) positive (B) negative (C) zero (D) can not be determined

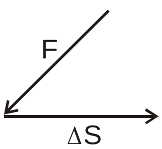
3. The work done by a person in keeping an object moving in a circular path by means of a thread is:

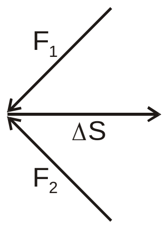
(A) positive (B) negative (C) zero (D) can not be determined

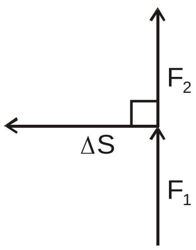
4. Determine the sign of net work done by all force shown in followin cases.

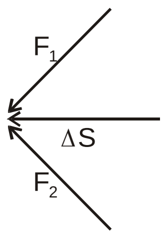
(i) 

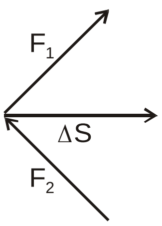
(ii) 

(iii) 

(iv) 

(v) 

(vi) 

(vii) 

(A) +ve (B) – ve (C) Zero (D) undeterminable

5. A chord is used to lower vertically a block of mass M a distance d at a constant downward acceleration of g/4. Then the work done by the cord on the block is :

(A) mg d/4 (B) 3 Mg d/4 (C) – 3 Mg d/4 (D) Mg d

6. A body moves a distance of 10 m along a straight line under the action of a force of 5 N. If the work done is 25 J, the angle which the force makes with the direction of motion of the body is :

(A) 0º (B) 30º (C) 60º (D) 90º

7. A chord is used to lower vertically a block of mass M a distance d at a constant downward acceleration of g/4. Then the work done by the cord on the block is :

(A) mg d/4 (B) 3 Mg d/4 (C) – 3 Mg d/4 (D) Mg d

8. A force of 3 N acts through a distance of 12 m in the direction of the force. Find the work done.

9. A horizontal force of 25 N pulls a box along a table. How much work does it do in pulling the box 80 cm?

10. A child pushes a toy box 4.0 m along the rough floor by means of a force of 6 N directed downward at an angle of 37º to the horizontal.

(a) How much work does the child do?

(b) Would you expect more or less work to be done for the same displacement if the child pulled upward at the same angle to the horizontal?

11. A horizontal force F pulls a 20 kg carton across the floor at constant speed. If the co-efficient of sliding friction between carton and floor is 0.60, how much work does F do in moving the carton 3.0 m ?

12. A box is dragged across a floor by a rope which makes an angle of 60º with the horizontal. The tension in the rop is 100 N while the box is dragged 15 m. How much work is done?

13. **Assertion :** The work done during a round trip is always zero.

Reason : No force is required to move a body in its round trip.

(A) If both Assertion and Reason are true and the Reason is correct explanation of Assertion.

(B) If both Assertion and Reason and true but Reason is not a correct explanation of Assertion

(C) If Assertion is true but Reason is false.

(D) If both Assertion and Reason are false.

(E) If Assertion is false but Reason is true.

14. **Assertion :** Work done by friction on a body sliding down an inclined plane is positive.

Reason : Work done is greater than zero, if angle between force and displacement is acute or both are in same direction.

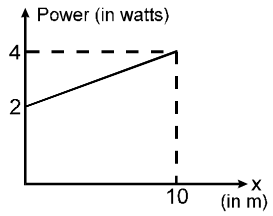
(A) If both Assertion and Reason are true and the Reason is correct explanation of Assertion.

(B) If both Assertion and Reason and true but Reason is not a correct explanation of Assertion

(C) If Assertion is true but Reason is false.

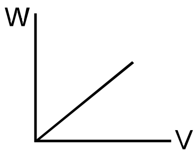
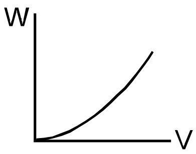
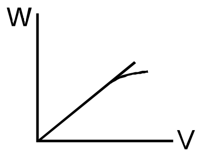
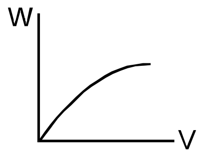
(D) If Assertion is false but Reason is true.

1. A particle A of mass $\frac{10}{7}$ kg is moving in the positive direction of x. Its initial position is x = 0 & initial velocity is 1 m/s. The velocity at x = 10 is : (use the graph given)



(A) 4 m/s (B) 2 m/s (C) $3\sqrt{2}$ m/s (D) 100/3 m/s

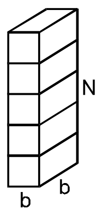
2. A particle, initially at rest on a frictionless horizontal surface, is acted upon by a horizontal force. A graph is plottedof the work done on the particle W, against the speed of the particle v. If there are no other horizontal forces acting on the particle the graph would be.

(A)  (B)  (C)  (D) 

3. A man pulls a bucket of water from a depth of h from a well. If the mass of the rope and that of bucket full of water are m and M respectively, the work done by the man is

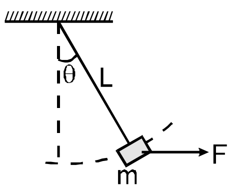
(A) (M + m)gh (B) $\left(M+\frac{m}{2}\right)gh$ (C) $\left(\frac{M+m}{2}\right)gh$ (D) $\left(\frac{M}{2}+m\right)gh$

4. N similar slab of cubical shape of edge b are lyging on ground. Density of material fo slab is D. Work done to arrange them one over the other is :



(A) $(N^2 - 1)\, b^3$ Dg (B) $(N - 1)\, b^4$ Dg (C) $1/2\, (N^2 - N)\, b^4$ Dg (D) $(N^2 - N)\, b^4$ Dg

5. An object of mass m is tied to string of length L and a variable horizontal force is applied on it which starts at zero and gradually increases (it is pulled extremely slowly so that equilibrium exists at all times) until the string makes an angle θ with the vertical. Work done by the force F is :

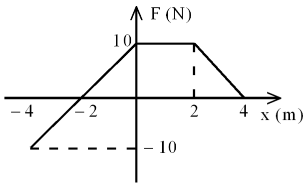


(A) mg L (1 – cos θ) (B) mg L (1 – sin θ) (C) mg L (D) mg L (1 + tan θ)

6. One end of a light spring of force constant k is fixed to the ceiling. The other end is fixed to a block of mass m. Initially the spring is relaxed. The work done by an external agent to lower the hanging body of mass m slowly till it comes to equilibrium is:

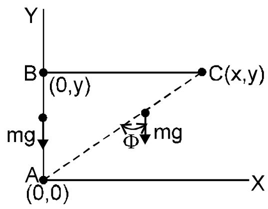
(A) $3\dfrac{m^2g^2}{2k}$ (B) $\dfrac{m^2g^2}{2k}$ (C) $-3\dfrac{m^2g^2}{2k}$ (D) $-\dfrac{m^2g^2}{2k}$

7. A force varies the position as shown in the figure . Find the work done by it from :



(a) $x = -4$ to $+4$ m (b) $x = 0$ to -2 m

8. In the figure shown, evaluate the work done by the weight mg acting on a particle of mass m, as the particle is moved (by the application of other forces) from



(A) A to B (B) B to A (C) A to B to C (D) A to C directly
(E) A to B to C to A

1. A uniform rope of length ℓ and mass m hangs over horizontal table with two third part on the table. The coefficient of friction between the table and the chain is μ. The work done by the friction during the period the chain slips completely off the table is

(A) $\frac{2}{9}\mu mg\ell$ (B) $\frac{2}{3}\mu mg\ell$ (C) $\frac{1}{3}\mu mg\ell$ (D) $\frac{1}{9}\mu mg\ell$

2. A spring, which is initially in its unstretched condition, is first stretched by a length x and then again by a further length x. The work done in the first case is W_1 and in the second case is W_2 :

(A) $W_2 = W_1$ (B) $W_2 = 2W_1$ (C) $W_2 = 3W_1$ (D) $W_2 = 4W_1$

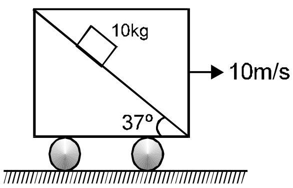
3. An object of mass m has a speed υ as it passes through the origin on its way out along with +x axis. The object is subjected to a retarding force given by $F = -Ax (A > 0)$. The x co-ordinate of the object when it stops is

(A) $\nu\sqrt{\frac{m}{A}}$ (B) $\nu\sqrt{\frac{2m}{A}}$ (C) $\nu\sqrt{\frac{m}{2A}}$ (D) $2\nu\sqrt{\frac{m}{A}}$

4. An elastic string of unstretched length L and force constat k is stretched by a small lengthx. It is further stretched by another small length y. The work done in the second stretching is

(A) $\frac{1}{2}ky^2$ (B) $\frac{1}{2}k(x^2 + y^2)$ (C) $\frac{1}{2}k(x + y)^2$ (D) $\frac{1}{2}ky(2x + y)$

5. A block of mass 10 kg is released on a fixed wedge inside a cart which is moved with constant velocity 10 m/s towards right. Take initial velocity of block with respect to cart zero. Then work done by normal reaction (with respect to ground)on block in two second will be: ($g = 10$ m/s^2).

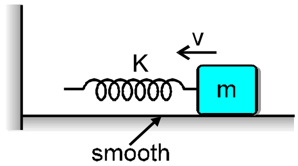


(A) zero (B) 960 J (C) 1200 J (D) None of these

6. An object is moving along a straight line path from P to Q under the action of a force $\vec{F} = (4\hat{i} - 3\hat{j} + 2\hat{k})$ N. If the co-ordinate of P & Q in metres are (3, 2, −1) & (2, −1, 4) respectively. Then the work done by the force is :

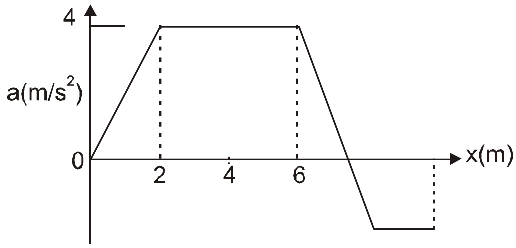
(A) − 15 J (B) + 15 J (C) 1015 J (D) $(4\hat{i} - 3\hat{j} + 2\hat{k})$

7. A block is attached with a spring and is moving towards a fixed wall with speed v as shown in figure. As the spring reaches the wall, it starts compressing. The work done by the spring on the wall during the process of compression is



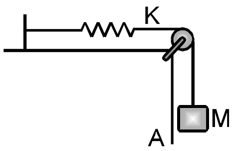
(A) 1/2 mv^2 (B) mv^2 (C) Kmv (D) zero

8. Graph shows the acceleration of a 3 kg particle as an applied force moves it from rest along x axis. The total work done by the force on the particle by the time the particle reaches x = 6 m, is equal to



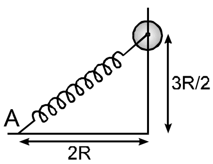
(A) 20 J (B) 30 J (C) 40 J (D) 60 J

9. Block A in the figure is released from rest when the extension in the spring is x_0. (x_0 < mg/k). The maximum downwards displacement of the block is (ther is no friction) :



(A) $\frac{2Mg}{K}-2x_0$ (B) $\frac{Mg}{2K}+x_0$ (C) $\frac{2Mg}{K}-x_0$ (D) $\frac{2Mg}{K}+x_0$

10. A ring of mass m can slide over a smooth vertical rod. The ring is connected to a spring of force constant K = $\frac{4mg}{R}$ where 2 R is the natural length of the spring. The other end of the spring is fixed to the ground at a horizontal distance 2 R from the base of the rod. The mass is released at a height of 1.5 R from ground.



(a) calculate the work done by the spring.

(b) calculate the velocity of the ring as it reaches the ground.

11. Figure shows a smooth curved track terminating in a smooth horizontal part. A spring of spring constant 400 N/m is attached at one end to a wedge fixed rigidly with the horizontal part. A 40 g mass is released from rest at a height of 4.9 m on the curved track. Find the maximum compression of the spring.

1. A particle is moving in a conservative force field point A to point B. U_A and U_B are the potential energies of the particle energies of the particle at points A and B and W_c is the work done in the process of taking the particle from A to B.

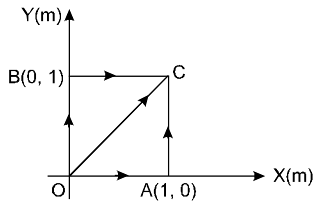
(A) $W_c = U_B - U_A$ (B) $W_c = U_A - U_B$ (C) $U_A > U_B$ (D) $U_B > U_A$

2. A particle is taken from point A to point B under the influence of a force field. Now it is taken back from B to A and it is observed that the work done in taking the particle from A to B is not equal to the work done in taking it from B to A. If W_{nc} and W_c is the work done by non-conservative forces and conservative forces present in the system respectively, ΔU is the change in potential energy, Δk is the change kinetic energy, then

(A) $W_{nc} - \Delta U = \Delta k$ (B) $W_c = -\Delta U$ (C) $W_{nc} + W_c = \Delta k$ (D) $W_{nc} - \Delta U = -\Delta k$

COMPREHENSION # 2

One of the forces acting on a certain particle depends on the particle's position in the xy-plane. This force $\vec{F}$ expressed in newtons, is given by the expression $\vec{F} = (xy\hat{i} + xy\hat{j})$ where x and y are in metres. The particle is moved from O to C through three different paths



3. The work done by this force on path OC is

(A) $\frac{1}{2}$ J (B) $-\frac{1}{2}$ J (C) $\frac{2}{3}$ J (D) $-\frac{2}{3}$ J

4. The work done by this force on path OAC is

(A) $\frac{1}{2}$ J (B) $-\frac{1}{2}$ J (C) $\frac{2}{3}$ J (D) $-\frac{2}{3}$ J

5. The work done by this force on path OBC is

(A) $\frac{1}{2}$ J (B) $-\frac{1}{2}$ J (C) $\frac{2}{3}$ J (D) $-\frac{2}{3}$ J

6. The force $\vec{F}$ is

(A) Conservative (B) Non-Conservative

(C) Can't be determined (D) None of these

7. The potential energy function of a particle in a region of space is given as $U = (2x^2 + 3y^3 + 2z)$J. Here x,y and z are in metres. Find the force acting on the particle at point P(1m, 2m, 3m).

(A) $\vec{F} = -(4\hat{i} + 36\hat{j} + 2\hat{k})$ N (B) $\vec{F} = (4\hat{i} + 36\hat{j} + 2\hat{k})$ N

(C) $\vec{F} = -(36\hat{i} + 4\hat{j} + 2\hat{k})$ N (D) $\vec{F} = -(4\hat{i} + 2\hat{j} + 36\hat{k})$ N

8. The potential energy function of a particle in a region of space is given as U = (2xy + yz) J. Here x, y and z are in metre. Find the force acting on the particle at a general point P(x, y, z)

(A) $\vec{F} = -[2x\hat{i} + (2y+z)\hat{j} + y\hat{k}]$ (B) $\vec{F} = [2y\hat{i} + (2x+z)\hat{j} + y\hat{k}]$

(C) $\vec{F} = -[2y\hat{i} + (2x+z)\hat{j} + y\hat{k}]$ (D) $\vec{F} = -[2y\hat{i} + (2x+y)\hat{j} + z\hat{k}]$

9. Which of the following can be negative ?

(A) Kinetic energy (B) Potential Energy (C) Mechanical Energy (D) All of these

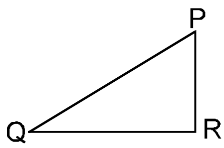
10. Which of the following may not be conserved ?

(A) Energy (B) Potential energy (C) Mechanical energy (D) Kinetic energy

11. A long spring is stretched by ' x ' cm and its potential energy is U. If the spring is stretched by Nx cm , the potential energy stored in it will be :

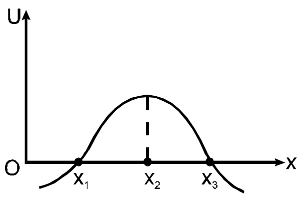
(A) U/N (B) NU (C) N^2U (D) U/N^2

12. For the path PQR in a conservative force field (fig.), the amounts work done in carrying a body from P to Q & from Q to R are 5 J & 2 J respectively . The work done in carrying the body from P to R will be



(A) 7 J (B) 3 J (C) $\sqrt{21}$ J (D) zero

13. In the figure shown the potential energy U of a particle is plotted against its position 'x' from origin. Then which of the following statement is correct. A particle at



(A) x_1 is in stable equilibrium (B) x_2 is in stable equilibrium

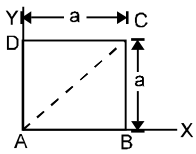
(C) x_3 is in stable equilibrium (D) none of these

14. Force acting on a particle in a conservative force field is :-

(i) $\vec{F} = (2\hat{i} + 3\hat{j})$ (ii) $\vec{F} = (2x\hat{i} + 3y^2\hat{j})$ (iii) $\vec{F} = (y\hat{i} + x\hat{j})$

Find the potential energy function if it is zero at origin is :-

15. A force F = x^2y^2i + x^2y^2j (N) acts on a particle which moves in the XY plane.



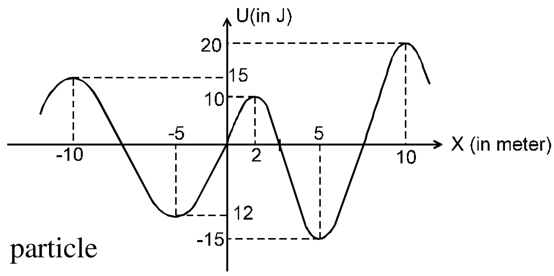
(a) Determine if F is conservative and

(b) find the work done by F as it moves the particle from A to C (fig.) along each of the paths ABC, ADC, and AC.

1. The potential energy of a particle of mass m free to move along x-axis is given by $U = \frac{1}{2}kx^2$ for $x < 0$ and $U = 0$ for $x \geq 0$ (x denotes the x-coordinate of the particle and k is a positive constant). If the total mechanical energy of the particle is E, then its speed at $x = -\sqrt{\frac{2E}{k}}$ is

(A) zero (B) $\sqrt{\frac{2E}{m}}$ (C) $\sqrt{\frac{E}{m}}$ (D) $\sqrt{\frac{E}{2m}}$

2. In the figure the variation of potential energy of a particle of mass m = 2kg is represented w.r.t. its x-coordinate. The particle moves under the effect of this conservative force along the x-axis. Which of the following statements is incorrect about the particle



(A) If it is released at the origin it will move in negative x-axis.

(B) If it is released at $x = 2 + \Delta$ where $\Delta \to 0$ then its maximum speed will be 5 m/s and it will perform oscillatory motion

(C) If initially $x = -10$ and $\vec{u} = \sqrt{6}\hat{i}$ then it will cross $x = 10$

(D) $x = -5$ and $x = +5$ are unstable equilibrium positions of the particle

3. The potential energy of a particle in a field is $U = \frac{a}{r^2} - \frac{b}{r}$, where a and b are constant. The value of r in terms of a and b where force on the particle is zero will be :

(A) $\frac{a}{b}$ (B) $\frac{b}{a}$ (C) $\frac{2a}{b}$ (D) $\frac{2b}{a}$

4. A dam is situated at a height of 550 m above sea level and supplies water to a power house which is at a height of 50 m above sea level. 2000 kg of water passes through the turbines per second. What would be the maximum electrical power output of the power house if the whole system were 80% efficient ?

(A) 8 MW (B) 10 MW (C) 12.5 MW (D) 16 MW

5. An elevator is rising at constant speed. Consider the following statements and pick up the statements which are correct :

(A) The upward cable force is constant.

(B) The kinetic energy of the elevator is constant.

(C) The gravitational potential energy of the Earth-elevator system is constant.

(D) The mechanical energy of the Earth-elevator system is constant

6. **Assertion :** A body cannot have kinetic energy without having momentum but it can have momentum without having kinetic energy.

Reasion : Momentum and kinetic energy have same dimensions.

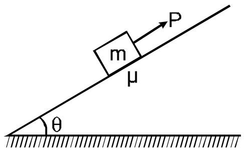
(A) If both Assertion and Reason are true and the Reason is correct explanation of Assertion.

(B) If both Assertion and Reason and true but Reason is not a correct explanation of Assertion

(C) If Assertion is true but Reason is false.

(D) If both Assertion and Reason are false.

7. A block of mass m is being pulled up the rough incline by an agent delivering constant power P. The coefficient of friction between the block and the incline is μ. The maximum speed of the block during the course of ascent is



(A) $v = \dfrac{P}{mg\sin\theta + \mu mg\cos\theta}$ (B) $v = \dfrac{P}{mg\sin\theta - \mu mg\cos\theta}$

(C) $v = \dfrac{2P}{mg\sin\theta - \mu mg\cos\theta}$ (D) $v = \dfrac{3P}{mg\sin\theta - \mu mg\cos\theta}$

8. An engine is pulling a train of mass m on a level track at a uniform speed υ. The resistive force offered per unit mass is f.

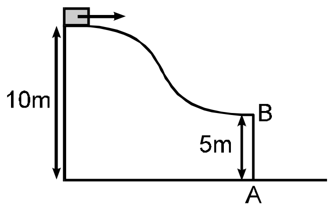
(A) Power produced by the engine is mfυ.

(B) The extra power developed by the engine to maintain a speed υ up a gradient of h in s is $\dfrac{mghv}{s}$

(C) The frictional force exerting on the train is mf on the level track

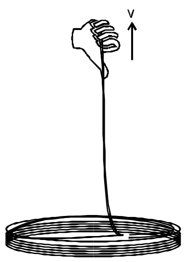
(D) None of above is correct

9. As shown in the figure a particle is released from highest point of curved smooth path. The distance of point of strike from A will be :



(A) 10 m (B) 5 m (C) 20 m (D) None of these

10. A uniform rope of linear mass density λ and length ℓ is coiled on a smooth horizontal surface. One end is pulled up with constant velocity v. Then the average power applied by the external agent in pulling the entire rope just off the ground is



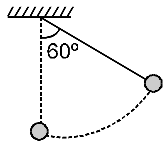
(A) $\dfrac{1}{2}\lambda\ell v^2 + \dfrac{\lambda\ell^2 g}{2}$ (B) $\lambda\ell gv$ (C) $\dfrac{1}{2}\lambda v^3 + \dfrac{\lambda\ell vg}{2}$ (D) $\lambda\ell gv + \dfrac{1}{2}\lambda v^3$ (E) $\lambda v^3 + \dfrac{\lambda\ell vg}{2}$

11. A 1kW motor supplies 1200 litre of water per minute of water. If demand increases to 1800 litre/minute, then what should be the power of new motor used keeping other things in supply system unchanged

1. Acceleration of a body moving with constant speed in a circle is :

(A) zero (B) $\omega \times r$ (C) $\frac{\omega^2}{r}$ (D) $\omega^2 r$

2. A pendulum of length l = 1 m is released from $\theta_0 = 60^\circ$. The rate of change of speed of the bob at $\theta = 30^\circ$ is ($g = 10\ m/s^2$)



(A) $5\sqrt{3}\ m/s^2$ (B) $5\ m/s^2$ (C) $10\ m/s^2$ (D) $2.5\ m/s^2$

3. A particle is revolving in a circle with increasing its speed uniformly . Which of the following is constant?

(A) Centripetal acceleration (B) Tangential acceleration

(C) Angular acceleration (D) None of these

4. Two particles A and B revolve concentrically in a horizontal plane in the same direction. The time required to complete one revolution for particle A is 3 min. while for particle B is 1 min. The time required for A to make one revolution relative to B is :

(A) 3 min (B) 1 min (C) 1.5 min (D) None of these

5. A particle moves along a circular path of constant radius. The magnitude of its acceleration is

(A) uniform (B) variable

(B) zero (D) such as cannot be predicted from the given information

6. What is angular displacement ? what are its units ? What is the angular displacement of a particle moving in a circle in :

(i) One rotation (ii) Half rotation (iii) Quarter rotation

7. A car goes around a traffic circle in 60 seconds. What is the angular displacement in 10 seconds ? (Give your answer in radians) ? What is the angular velocity in rad/sec.

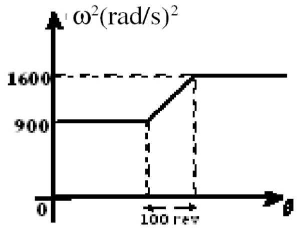
8. Find the angular velocity of the earth around the sun. (Assume it to have a circular path and a non-leap year). Similarly find the angular velocity of the moon (Moon takes 29 days to complete one revolution of earth). Give your answer in rad/sec.

9. A fan rotating at an angular velocity of 20π radian/sec. is switched off. It is observed that the fan stops in 20 seconds. Find the angular deceleration of the fan and the number of revolutions made by it till it stops.

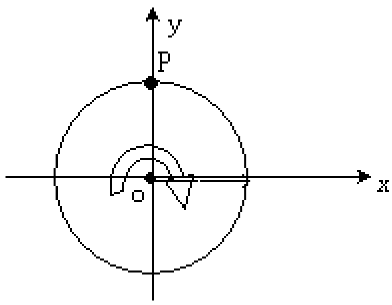
10. If a body moving in a circle of radius 2 m has a velocity of 4 m/s. Find its angular velocity.

11. Find the acceleration of a particle placed on the surface of the earth at equator due to earth's rotation. The diameter of earth = 12800 km. the period of earth's rotation = 24 hrs.

12. The square of the angular velocity ω of a certain wheel increases linearly with the angular displacement during 100 rev of the wheel's motion as shown. Compute the time t required for the increase .



13. A ring of radius 1 m rotates about z axis as shown in figure . The plane of rotation is xy. At a certain instant the acceleration of a particle P (shown in figure) on the ring is, $\vec{a} = -3\hat{i} - 4\hat{j}$ m/s^2 . At that instant angular acceleration of the ring is _______ & the angular velocity is _______ .



14. A particle starts moving at t = 0 in a circle of radius R = 2 m with constant angular acceleration of α = 3 rad/sec^2. Initial angular speed of the particle is 1 rad/sec. At the instant when the angle between the acceleration vector and the velocity vector of the particle is 37°, calculate ;

(a) the value of 't' at this moment

(b) magnitude of the acceleration of the particle

(c) distance travelled by the particle upto this moment

15. A stone weighing 50 g tied to one end of the string is to be rotated in a horizontal circle of 1 metre with a speed of 5 ms^{-1}. The centripetal force required to do so is _________.

16. A flywheel makes 600 rpm. The angular speed of any point on the wheel and the linear speed of a point 5 cm from the centre of the wheel are _________.

1. A particle of mass m describes a circle of radius r. The centripetal acceleration of the particle is $4/r^2$. What will be the momentum of the particle ?

(A) $2\frac{m}{r}$ (B) $2\frac{m}{\sqrt{r}}$ (C) $4\frac{m}{\sqrt{r}}$ (D) none

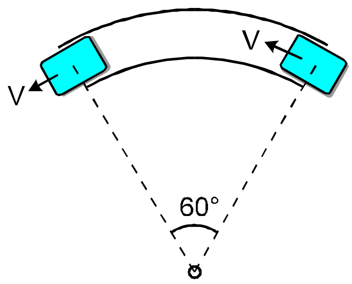
2. A particle is revolving in a circle of radius R with initial speed u. It starts retarding with constant retardation $\frac{u^2}{4\pi R}$. The number of revolutions it makes in time $\frac{8\pi R}{u}$ is

(A) 3 (B) 4 (C) 2 (D) None of these

3. Two bodies having masses 10 kg and 5 kg are moving in concentric orbits of radii 4 and 8 such that their time periods are the same. Then the ratio of their centripetal accelerations is

(A) $\frac{1}{2}$ (B) 2 (C) 8 (D) $\frac{1}{8}$

4. A car moves around a curve at a constant speed. When the car goes around the arc subtending 60° at the centre, then the ratio of magnitude of instantaneous acceleration to average acceleration over the 60° arc is :

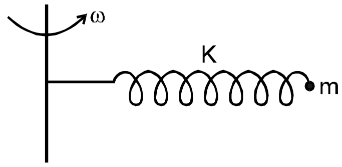


(A) $\frac{\pi}{3}$ (B) $\frac{\pi}{6}$ (C) $\frac{2\pi}{3}$ (D) $\frac{5\pi}{3}$

5. An object follows a curved path. The following quantities may remain constant during the motion

(A) Ppeed (B) Velocity (C) Acceleration (D) Magnitude of acceleration

6. A particle of mass m is fixed to one end of a light spring of force constant k and unstretched length ℓ. The system is rotated about the other end of the spring with an angular velocity ω in gravity free space. The increase in length of the spring is :



(A) $\frac{m\omega^2\ell}{k}$ (B) $\frac{m\omega^2\ell}{k-m\omega^2}$ (C) $\frac{m\omega^2\ell}{k+m\omega^2}$ (D) None of these

7. A particle is moving in a circular path. The acceleration and momentum vectors at an instant of time are $\vec{a} = 2\hat{i} + 3\hat{j}$

m/s^2 and $\vec{P} = 6\hat{i} - 4\hat{j}$ kgm/s. Then the motion of the particle is

(A) Uniform circular motion (B) Circular motion with tangential acceleration

(C) Circular motion with tangential retardation (D) We cannot say anything from $\vec{a}$ and $\vec{P}$

8. A stone of mass 1 kg tied to the end of a string of length 1 m, is whirled in a horizontal circle (string is horizontal), with a uniform angular speed of 2 rad/sec. Then the tension in the string will be :

(A) 4 N (B) 8 N (C) 1 N (D) 2 N

9. A heavy particle is tied to the end A of a string of length 1.6 m. Its other end O is fixed. It revolves as a conical pendulum with the string making 60° with the vertical. Then

(A) its period of revolution is $\frac{4\pi}{7}$ sec.

(B) the tension in the string is doubled the weight of the particle

(C) the velocity of the particle = $2.8\sqrt{3}$ m/s

(D) the centripetal acceleration of the particle is $9.8\sqrt{3}$ m/s^2.

10. If the apparent weight of the bodies at the equator is to be zero, then the earth should rotate with angular velocity

(A) $\sqrt{\frac{g}{R}}$ rad/sec (B) $\sqrt{\frac{2g}{R}}$ rad/sec

(C) $\sqrt{\frac{g}{2R}}$ rad/sec (D) $\sqrt{\frac{3g}{2R}}$ rad/sec

11. Two bodies A & B separated by a distance $2R$ are moving counter clockwise along a circular path of radius R each with uniform speed v . At time t = 0, A is given a constant tangential acceleration $a = \frac{72\,v^2}{25\,\pi\,R}$. Find

(i) The time lapse for the two bodies to collide

(ii) The angle covered by A

(iii) Angular velocity of A

(iv) Radial acceleration of A

1. A mass M slides down a curved frictionless track in vertical plane, starting from rest. The curve obeys the equation $y = x^2/2$. The tangential acceleration of the mass is :

(A) g

(B) $\frac{gx}{\sqrt{x^2+4}}$

(C) $\frac{g}{2}$

(D) $\frac{gx}{\sqrt{x^2+1}}$

2. A heavy particle is projected from a point on the horizontal at an angle 60° with the horizontal with a speed of 10 m/s. Then the radius of the curvature of its path at the instant of crossing the same horizontal is

(A) infinite (B) 10 m (C) 11.54 m (D) 20 m

3. A motorcyclist of mass m is to negotiate a curve of radius r with a speed v. The minimum value of the coefficient of friction so that negotiatiion may take place safely, is

(A) v^2rg

(B) $\frac{v^2}{gr}$

(C) $\frac{gr}{v^2}$

(D) $\frac{g}{v^2r}$

4. Which of the following statements about the centripetal and centrifugal forces is correct ?

(A) Centripetal force balances the centrifugal force

(B) Both centripetal force and centrifugal force act on the same body

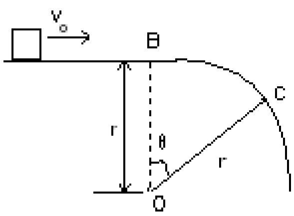
(C) Centripetal force is directed opposite to the centrifugal force

(D) Centripetal force is experienced by the observer at the centre of the circular path described by the body

5. A motor cyclist wants to drive on the vertical surface of a wooden 'well' of radius 5m, with a minimum speed of $5\sqrt{5}$. The minimum value of coefficient of friction between the tyres and the wall of the well must be -

(A) 0.10 (B) 0.20 (C) 0.30 (D) 0.40

6. A small block slides with velocity $0.5\sqrt{gr}$ on the horizontal frictionless surface as shown in the Figure. The block leaves the surface at point C. The angle θ in the Figure is

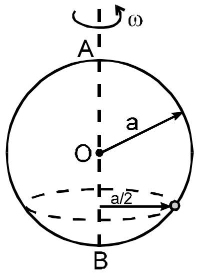


(A) $\cos^{-1}(4/9)$

(B) $\cos^{-1}(3/4)$

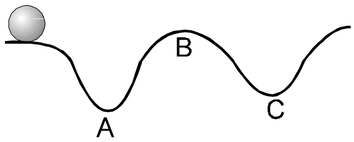
(C) $\cos^{-1}(1/2)$ (D) None of these

7. A smooth wire is bent into a vertical circle of radius ***a***. A bead P can slide smoothly on the wire. The circle is rotated about diameter AB as axis with a speed ω as shown in figure. The bead P is at rest w.r.t. the circular ring in the position shown. Then ω^2 is equal to :



(A) $\frac{2g}{a}$ (B) $\frac{2g}{a\sqrt{3}}$ (C) $\frac{g\sqrt{3}}{a}$ (D) $\frac{2a}{g\sqrt{3}}$

8. A body moves along an uneven surface with constant speed at all points. The normal reaction of the road on the body is



(A) maximum at A (B) maximum at B (C) minimum at C (D) the same at A, B & C

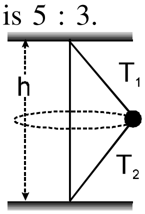
9. In the motorcycle stunt called "the well of death" the track is a vertical cylindrical surface of 18 m radius. Take the motorcycle to be a point mass and μ = 0.8. The minimum angular speed of the motorcycle to prevent him from sliding down should be

(A) 6/5 rad/s (B) 5/6 rad/s (C) 25/3 rad/s (D) none of these

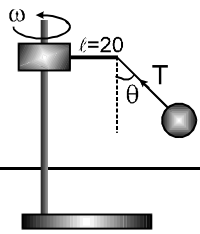
10. A particle begins to move with a tangential acceleration of constant magnitude 0.6 m/s^2 in a circular path. If it slips when its total acceleration becomes 1 m/s^2, then the angle through which it would have turned before it starts to slip is

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

11. A particle is attached by means of two equal strings to points A and B in the same vertical line and decribe a horizontal circle with a uniform angular speed. If the angular speed of the particle is $2\sqrt{(2g/h)}$ with AB = h, show that the ratio of the tension of the string is 5 : 3.



12. Figure on the right shows a rod of length 20 cm pivoted near an end and which is made to rotate in a horizontal plane with a constant angular speed. A ball of mass m is suspended by a string also of length 20 cm from the other end of the rod. If the angle θ made by the string with the vertical is 30º, find the angular speed of rotation. Take g = 10 m/s^2.



1. A system consists of 3 particles each of mass m and located at (1, 1) (2, 2) (3, 3). The co-ordinates of the centre of mass are

(A) (6, 6) (B) (3, 3) (C) (2, 2) (D) (1, 1)

2. Two identical balls each of radius 10 cm are placed touching each other. The distance of their centre of mass from the point of contact is :

(A) zero (B) 5 cm (C) 10 cm (D) 15 cm

3. Four identical spheres each of radius 10 cm and mass 1 kg each are placed on a horizontal surface touching one another so that their centres are located at the corners of square of side 20 cm.

What is the distance of their centre of mass from centre of either sphere ?

(A) 5 cm (B) 10 cm (C) 20 cm (D) None of the above

4. Two atoms of the hydrogen are located at $\vec{r}_1$ and $\vec{r}_2$. Their centre of mass is at :

(A) $\frac{\vec{r}_1-\vec{r}_2}{2}$ (B) $\frac{\vec{r}_1+\vec{r}_2}{2}$ (C) $\vec{r}_1-\vec{r}_2$ (D) $\vec{r}_1+\vec{r}_2$

5. The separation between carbon and oxygen molecules in CO is 0.12 nm. What is the distance of the centre of mass from carbon atom ?

(A) 0.03 nm (B) 0.05 nm (C) 0.07 nm (D) 0.09 nm

6. Four identical spheres each of mass m are placed at the corners of square of side 2m. Taking the point of intersection of the diagonals as the origin, the co-ordinates of the centre of mass are :

(A) (0, 0) (B) (1, 1) (C) (–1, 1) (D)(1, –1)

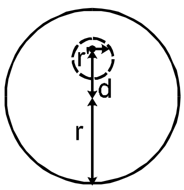
7. Three identical spheres each of mass M are placed at the corners of an equilateral triangle of side 2 m. Taking one of the corners as the origin, the position vector of the centre of mass is :

(A) $\hat{i}+\sqrt{3}\,\hat{j}$ (B) $\sqrt{3}\,\hat{i}+\hat{j}$ (C) $\hat{i}+\frac{\hat{j}}{\sqrt{3}}$ (D) $\frac{\hat{i}}{\sqrt{3}}+\hat{j}$

8. Three identical spheres each of mass M are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 2m. Taking their point of intersection as the origin, the position vector of the centre of mass is :

(A) $\frac{2}{3}(\hat{i}+\hat{j})$ (B) $\frac{2}{3}(\hat{i}-\hat{j})$ (C) $\frac{1}{3}(\hat{i}+\hat{j})$ (D) $\frac{1}{3}(\hat{i}-\hat{j})$

9. A uniform circular of disc has radius r. A circular portion or radius r'. A circular portion of radius r' is removed from it. The centre of hole is at a distance d from the centre of disc. the position of centre of mass of the disc with hole is given by :



(A) $\frac{dr'}{(r-r')^2}$ (B) $\frac{dr'^2}{r-r'}$ (C) $-\frac{dr'^2}{r-r'}$ (D) $-\frac{dr'^2}{r^2-r'^2}$

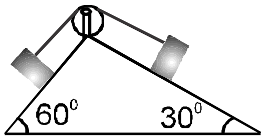
10. Two particles of mass 1 kg and 3 kg have position vectors $2\hat{i}+3\hat{j}+4\hat{k}$ and $-2\hat{i}+3\hat{j}-4\hat{k}$ respectively. The centre of mass has a position vector.

(A) $\hat{i}+3\hat{j}-2\hat{k}$ (B) $-\hat{i}-3\hat{j}-2\hat{k}$ (C) $-\hat{i}+3\hat{j}+2\hat{k}$ (D) $-\hat{i}+3\hat{j}-2\hat{k}$

11. Initially stable two particles x and y start moving towards each other under mutual attraction. If at one time the velocities of X and Y are V and 2V respectively, what will be the velocity of centre of mass of the system ?

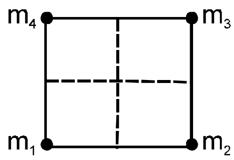
(A) V (B) V/2 (C) V/3 (D) zero

12. Two blocks of equal mass are ties with a light string which passes over a massless pulley as shown in figure. The magnitude of acceleration of centre of mass of both the blocks is (neglect friction everywhere):



(A) $\frac{\sqrt{3}-1}{4\sqrt{2}}g$ (B) $(\sqrt{3}-1)g$ (C) $\frac{g}{2}$ (D) $\left(\frac{\sqrt{3}-1}{\sqrt{2}}\right)g$

13. Four particles of masses $m_1 = 2m$, $m_2 = 4m$, $m_3 = m$ and m_4 are placed at four corners of a square. What should be the value of m_4 so that the centres of mass of all the four particles are exactly at the centre of the square ?



(A) 2m (B) 8m (C) 6m (D) none of these

14. Two particles of equal masses have velocities $\vec{V_1} = 2\hat{i}$ m/s .The first particle has an acceleration $\vec{a_1} = (3\hat{i}+3\hat{j})\frac{m}{s^2}$. while the acceleration of the other particle is zero. The centre of mass of the particles moves in a :

(A) Circle (B) Parabola (C) Straight line (D) Ellipse

15. Mass is non-uniformly distributed on the circumference of a ring of radius a and centre at origin. Let b the distance of centre of mass of the ring from origin. Then :

(A) $b = a$ (B) $0 \le b \le a$ (C) $b < a$ (D) $b > a$

16. In which of the following cases the centre of mass of a rod is certainly not at its centre ?

(A) The density continuously increases from left to right.

(B) The density continuously decreases from left to right.

(C) The density decreases from left to right upto centre and then increases.

(D) The density increases from left to right upto centre and then decreases.

ANSWER KEY

RACE - 21

1. (A) **2.** (B) **3.** (B) **4.** (A) **5.** (D) **6.** (C) **7.** (C) **8.** (A) **9.** (D)
10. (C) **11.** (D) **12.** (C) **13.** (D) **14.** (ABD)

RACE - 22

1. (B) **2.** (A) **3.** (C) **4.** (i) A (ii) A (iii) B (iv) B (v) C (vi) A (vii) D **5.** (C)
6. (C) **7.** (C) **8.** (B) **9.** 36 J **10.** 20J **11.** (a) 19.2 J (b) less work **12.** 353 J
13. 750 J **14.** (D) **15.** (D)

RACE - 23

1. (A) **2.** (B) **3.** (B) **4.** (C) **5.** (A) **6.** (D) **7.** (a) 30 J (b) – 10 J
8. (a) – mgy (b) mgy (c) – mgy (d) – mgy (e) 0

RACE - 24

1. (A) **2.** (C) **3.** (A) **4.** (D) **5.** (B) **6.** (B) **7.** (D) **8.** (D) **9.** (A)

10. $\frac{mg\,R}{2}, 2\sqrt{gR}$ **11.** 9.8 cm

RACE - 25

1. (B) **2.** (ABC) **3.** (C) **4.** (A) **5.** (A) **6.** (B) **7.** (A) **8.** (C) **9.** (BC)
10. (BCD) **11.** (C) **12.** (A) **13.** (D) **14.** (i) $U(x, y, z) = (-2x - 3y)$ (ii) $U(x, y, z) = -(x^2 + y^3)$

(iii) $U(x, y, z) = -xy$ **15.** (b) $W_{ABC} = W_{ADC} = \frac{a^5}{3}$ (J), $W_{AC} = \frac{2a^5}{5}$ (J)

RACE - 26

1. (A) **2.** (D) **3.** (C) **4.** (A) **5.** (AB) **6.** (D) **7.** (A) **8.** (ABC) **9.** (A)

10. (C) **11.** $p' = n^3p,\ p' = \frac{27}{8}$ kw

RACE - 27

1. (D) **2.** (B) **3.** (C) **4.** (C) **5.** (D) **6.** $2\pi, \pi, \frac{\pi}{2}$ **7.** $\frac{\pi}{3}$ rad, $\frac{\pi}{30}$ rad/s

8. $\omega_e = \frac{2\pi}{365\times24\times60\times60}, \omega_m = \frac{2\pi}{29\times24\times60\times60}$ **9.** $\alpha = \pi$ rad/sec^2. 10 revolutions

10. $\omega = \frac{V}{r} = \frac{4}{2} = 2$ rad/sec. **11.** 0.033 m/s^2 **12.** $\frac{40\pi}{7}$ **13.** 3 rad/s^2 , 2 rad/s^2

14. (a) $\frac{1}{6}$ sec (b) 7.5 (c) $\frac{5}{12}$ **15.** 1.25 N **16.** $100\,\pi$ cm s^{-1}

RACE - 28

1. (B) **2.** (C) **3.** (A) **4.** (A) **5.** (C) **6.** (B) **7.** (D) **8.** (A) **9.** (A, B, C , D)

10. (A) **11.** (i) $\frac{5\,\pi\,R}{6\,v}$ sec (ii) $\frac{11\,\pi}{6}$ (iii) $\frac{17\,v}{5\,R}$ (iv) $\frac{289\,v^2}{25\,R}$

RACE - 29

1.	(D)	**2.**	(D)	**3.**	(B)	**4.**	(C)	**5.**	(D)	**6.**	(B)	**7.**	(B)	**8.**	(A)		
9.	(B)	**10.**	(B)	**11.**		**12.**	$\omega = 4.4$ rad/sec										

RACE - 30

1.	(C)	**2.**	(A)	**3.**	(D)	**4.**	(B)	**5.**	(C)	**6.**	(A)	**7.**	(C)	**8.**	(A)	**9.**	(D)
10.	(D)	**11.**	(D)	**12.**	(A)	**13.**	(D)	**14.**	(C)	**15.**	(B)	**16.**	(A, B)				