NARAYANA EDUCATIONAL INSTITUTIONS

SUBJECT : NEWTON'S LAWS OF MOTION

1. A bullet 30 gm leaves the barrel of gun with a velocity of 900 m/sec. If the barrel of gun is 50 cm long and mass 9 kg then the value of impulse supplied to the gun will be
A)27 NS B)6 NS C)36 NS D)3 NS

2. A body of mass 1000gm moves along x-axis such that it's velocity varies with displacement x according to the relation $V = 6\sqrt{x}\, m/\sec$ the force acting on the body is
A) 20 N B)25 N C) 18 N D)50 N

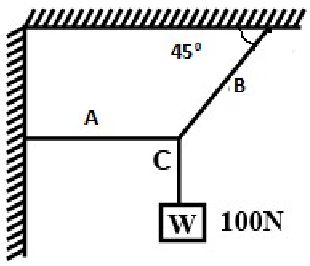
3. At any instant the velocity of a particle of mass 200gm is $\left(4t\hat{i} + 5t^2\hat{j}\right) m/\sec$. If the force acting on the particle at t=3 sec is $\left(i + xj\right) N$. Then the value of x will be
A)4 B)6 C)2 D)3

4. Force acts for 10sec on a body of mass 30kg, starting from rest, after which the force ceases and then body describes 100m in the next 5sec. the value of force will be
A)10 N B)15 N C) 30 N D) 60 N

5. Two billiard balls each of mass 0.05kg moving in opposite direction with speed of 6m/sec collide and rebound with the same speed. What is the impulse imparted to each ball by the other(NS)
A) $0.6\hat{i}\ Nsee, -0.6\hat{i}Nse$ B) $0.3\hat{i}. -0.3\hat{i}$ C) $0.6\hat{j}, 0.3\hat{i}$ D) $0.5\hat{i}, -0.5\hat{i}$

6. A rocket of initial mass 6000kg ejects mass at a constant rate of 16kg/s with constant relative speed of 11 km/sec. what is the acceleration of the rocket a minute after the blast?(Neglect gravity)
A) $50m/\sec^2$ B) $34.92m/\sec^2$ C) $44.92m/\sec^2$ D) $20m/\sec^2$

7. Find the tension in B cord as shown in figure. The weight of the suspended body is 100N.



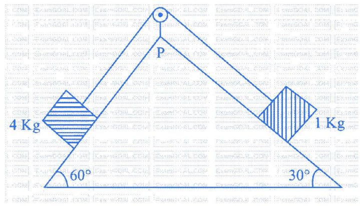
A)100N B) $200\sqrt{2}N$ C) $100\sqrt{2}N$ D) $400N$

8. The position vector of a particle related to time t is given by $\vec{r} = \left(10t^2\hat{i} + 20t\hat{j} + 7\hat{k}\right)m$ the direction of net force experienced by the particle is
A)Positive y-axis B)Positive x-axis C)Positive z-axis D)In x-y plane

9. A particle of mass m is acted upon by a force F given by the empirical law $F = \frac{R}{t^2}V(t)$. If the law is to tested experimentally by t^2 observing the motion starting from rest, the best way is to plot:

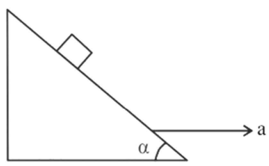
A)V(t) against t^2 B)log(t)against $\frac{1}{t^2}$ C)Log V(t)against $\frac{1}{t}$ D)LogV(t)against t

10. As per given figure, a weight less pulley p is attached on a double inclined frictionless surface. The tension in the string (mass less) will be (g=10 m/sec^2)



A) $\left(4\sqrt{3}+1\right)$N B) $4\left(\sqrt{3}+1\right)N$ C) $4\left(\sqrt{3}-1\right)N$ D) $\left(4\sqrt{3}-1\right)N$

11. A block is kept on a frictionless inclined surface with angle of inclination $'\alpha'$. The incline is given an acceleration 'a' to keep the block stationary. Then a is equal to

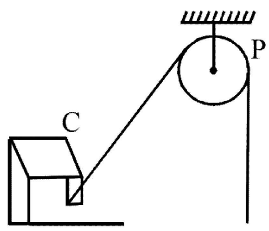


A) $g\ \text{Tan}\,\alpha$ B) $g\cos ec\,\alpha$ C) $\frac{g}{\text{Tan}\,\alpha}$ D)g

12. A mass of 20kg is suspended vertically by a rope of length 6m from the roof. A force of 50 N is applied at the middle point of a rope in horizontal direction. The angle made by upper half of the rope with vertical is $\theta = \tan^{-1}\left(x \times 10^{-2}\right)$. The value of x is ____(given g=10m/sec^2)

A)30 B)20 C)15 D)25

13. One end of a massless rope, which passes over a massless and frictionless pulley P is tied to a hook C while the other end is free. Maximum tension that the rope can bear is 360N. With what value of maximum safe acceleration (in ms^{-2})can a man of 60kg climb on the rope?

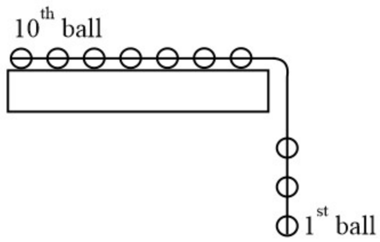


A)16 B)6 C)4 D)8

14. A block of metal weighing 2kg is resting on a frictionless plane. It is struck by a jet releasing water at a rate of 1kg/sec and at a speed of 5m/sec. the initial acceleration of the block will be (m/sec^2)

A)2.5 B)3.5 C)4.5 D)1.5

15. A system of 10 balls each of mass 2kg are connected via massless and stretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is _________N when 6th ball just leaves the table



A)26 N B)36 N C)50 N D)20 N

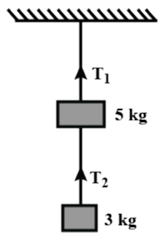
16. A man of 50kg is running on the road and suddenly jumps in to a stationary trolly car of mass 100kg. then the trolly car starts moving with velocity 4m/sec. the velocity of running man was_____m/sec. when he jumps in to the car.

A)6 m/sec B)3 m/sec C)12 m/sec D)10 m/sec

17. A spaceship in space sweeps stationary inter planetary dust. As a result its mass increases at a rate $\frac{dM(t)}{dt} = bV^2(t)$, where V(t) is its instantaneous velocity. The instantaneous acceleration of the satellite is

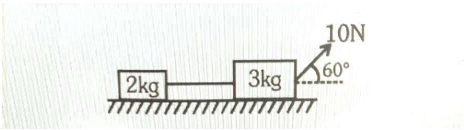
A) $-bv^3(t)$ B) $-\frac{bv^3}{M(t)}$ C) $-\frac{2bv^3}{M(t)}$ D) $-\frac{bv^3}{2M(t)}$

18. Two masses of 5kg and 3kg are suspended with the help of massless inextensible string as shown in figure. Calculate T_1 & T_2 when whole system is going upwards with acceleration $= 2m/\sec^2$ (use $g = 9.8m/\sec^2$)



A)94.4N,35.4N B)110N, 120 N C)74.4N,25.4N D)25.4N.74.4N

19. Find the tension in the string which connected the blocks as shown in the following figure.



A)2 N B)3 N C)5 N D)10 N

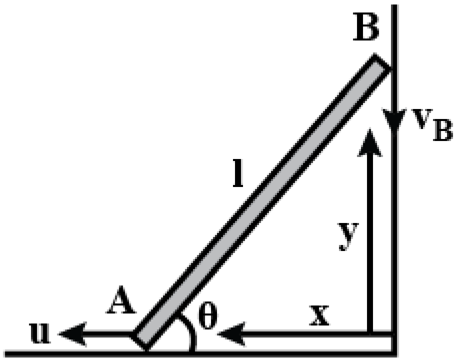
20. A particle moves xy-plane under the influence of a force such that its linear momentum is $\vec{p}(t) = A\left[\hat{i}\cos(kt) - \hat{j}\sin(kt)\right]$, where A and K are constant. The angle between the force and the momentum is

A) 0^0 B) 30^0 C) 45^0 D) 90^0

21. Two weight are suspended from a string thrown over a light frictionless pulley. The mass of one weight is 2kg. If a heavy weight is attached to its other end, the tension in the string is (g=10 m/sec^2)

A)Zero B)20 N C)40 N D)50 N

22. A rod AB of length L is leaning on a wall and the floor at an angle θ as shown fig. the end A is moved with a constant velocity u to left. Find the velocity V with which the end B moves downwards.

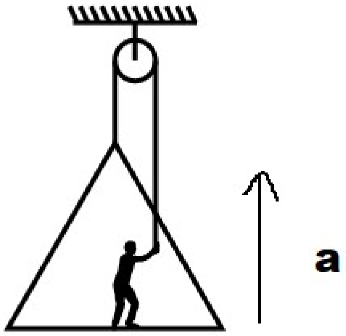


A) $V = u\cot\theta$ B) $V = 4\tan\theta$ C) $V = u$ D) $V = \sin\theta$

23. A thick uniform rope of mass 6kg and length 3m is hanging vertically from a rigid support. The tension in the rope at a point 1m from the support will be (Take g=10 m/sec^2)

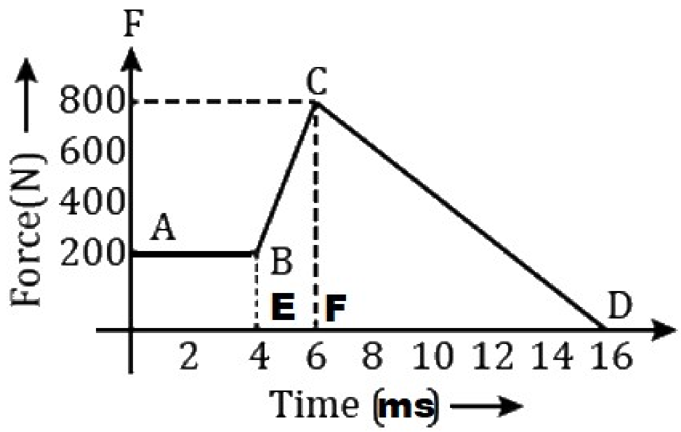
A)20 N B)30 N C)40 N D)60 N

24. A man of mass M stand on the floor of a box of mass m as shown in fig. he raises himself and the box with acceleration a=g/3 by means of a rope going over a fixed frictionless pulley. If the mass of the rope is negligible compared to (M+m) and if M=2m, the tension in the rope will be



A)2 mg B) $\frac{2mg}{3}$ C)mg D) $\frac{4mg}{3}$

25. The magnitude of Force F (in newton) acting on a body varies with time t(in millisecond) as shown in fig. find the magnitude of total impulse (in Ns) of the force on the body from t=4ms to t=16ms.



A)100Ns B)5Ns C)6Ns D)4Ns

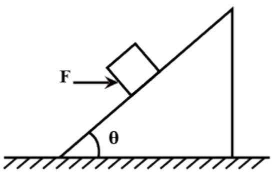
26. A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 100N, when the lift is stationary if the lift moves down wards with an acceleration of 5 m/sec^2, the reading of the spring balance will be
A)20 N B)50 N C) 60 N D) 70 N

27. A particle of mass 0.3kg subject to a force F=-kx, with K=15 N/m, what will be its initial acceleration if it is released from a point 20 cm away from the origin
A)15 m/sec^2 B)3 m/sec^2 C)10 m/sec^2 D)5 m/sec^2

28. The momenta of a body in two perpendicular direction at any time 't' are given by $Px = 3t^2 + 6$ and $P_y = \frac{2 + t^2 + 3}{2}$. The force acting on the body at $t = 1\sec$
A) $2\sqrt{10}N$ B) $4\sqrt{10}N$ C)10 N D) $2\sqrt{2}N$

29. A ball of mass 0.2kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m while applying the force and the ball goes up to 2m height further, find the force magnitude of the force $\left(g = 10m/\sec^2\right)$.
A)4 N B)16 N C)20 N D)22 N

30. A block of mass 500 gm is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x}N$ as shown in figure. The value of x is _____________



A)10 B)25 C)15 D)30

KEY

1	**A**	2	**C**	3	**B**	4	**D**	5	**A**
6	**B**	7	**C**	8	**B**	9	**C**	10	**B**
11	**A**	12	**D**	13	**C**	14	**A**	15	**B**
16	**C**	17	**B**	18	**A**	19	**A**	20	**D**
21	**C**	22	**A**	23	**C**	24	**B**	25	**B**
26	**B**	27	**C**	28	**A**	29	**D**	30	**B**

SOLUTIONS :

1. According law of conservation of momentum

$mu_1 + m_2u_2 = m_1v_1 + m_2\vartheta_2$

$0 = 9(-v) + 0.03(900 - v)$

$0 = 9v + 27 - 0.03v$

$0 = -9.03v + 27$

$9.03v = 27$

$v = 3m/\sec$

impulse on gun $= 9 \times 3 = 27Ns$

2. mass of body m$= \frac{1000}{1000} = 1kg$

velocity $v = 6\sqrt{x}$

$v^2 = 36x$

$\therefore 2v\frac{dv}{dx} = 36$

$V\frac{dv}{dx} = 18$

$\frac{dx}{dt}.\frac{dv}{dx} = 18$

$\frac{dv}{dt} = 18$

$a = 18m/\sec^2$

$\therefore$ Force $F = ma = 1 \times 18 = 18N$

3. Mass of particle m=20gm=0.2kg velocity of a particle

$V = 4t\hat{i} + 5t^2\hat{j}$

$a = \frac{dv}{dt} = 4\hat{i} + 10t\hat{j}$

at t=3sec

$a = 4\hat{i} + 30\hat{j}$

Force acting on the particle

$\vec{F} = m\vec{a}$

$\vec{F} = 0.2(4i + 30j)$

$F = (0.8i + 6j)N$

Hence x=6

4. Assume surface to be frictionless then

$100 = v \times 5$

$v = 20m/\sec$

as $v = u + at$

$v = 0 + a \times 10$

$20 = a \times 10$

$a = 2m/\sec^2$

$F = ma$

$F = 30 \times 2 = 60N$

5. For ball A

$\overrightarrow{Pi} = 0.05 \times 6\hat{i} = 0.3\hat{i}Ns$

$p_f = 0.05 \times (-6)\hat{i}Ns = -0.3\hat{i}N\sec$

impulse imparted to ball A due to ball B

$\vec{J}AB = \vec{P}_f - \vec{P}_i$

$= -0.3\hat{i} - 0.3\hat{i} = -0.6\hat{i}Ns$

For ball B: $\vec{P}_i = 0.05 \times (-6)\hat{i} = -0.3\hat{i}Ns$

$P_f = 0.05 \times (6)\hat{i} = 0.3\hat{i}Ns$

Impulse imparted to ball B due to ball A

$J_{BA} = P_f - P_i$

$= 0.3\hat{i} - (-0.3\hat{i}) = 0.6\hat{i}N\sec$

6. initial mass of rocket

$m_o = 6000kg$ and $\frac{dm}{dt} = 16kg/\sec$

the mass of the rocket after 1 minute of the blast $m = m_0 - \left(\frac{dm}{dt}\right)dt$

$= 6000 - 16 \times 60$

$= 5040$ kg

acceleration of the rocket is $a = \frac{V_r}{m}\left(\frac{dm}{dt}\right) - g$

$= \frac{11000}{5040} \times 16 - 0$

$= \frac{11000}{5040} \times 16$

$a = 34.92m/\sec$

7. By Lamils theorem, we have

$$\frac{TA}{\sin 135^0} = \frac{TB}{\sin 90^0} = \frac{TC}{\sin 135^0}$$

$$T_B = \frac{T_C}{\sin 135} \qquad (T_C = 100N)$$

$$T_B = \frac{100}{\frac{1}{\sqrt{2}}} = 100\sqrt{2}N$$

8. $\vec{r} = \left(10t^2\hat{i} + 20t + \hat{j} + 7\hat{k}\right)m$

$$\vec{v} = \frac{d\vec{r}}{dt} = 20t\hat{i} + 20j$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 20\hat{i}\,(\because F = ma)$$

So net Force in along $+x - axis$

9. From $F = \frac{R}{t^2}V(t)$

$$\Rightarrow m\frac{dv}{dt} = \frac{R}{t^2}V(t)$$

Integrating both sides $\int \frac{dv}{V} = \int \frac{Rdt}{mt^2}$

$$\log V = -\frac{R}{mt}$$

$$\therefore \log v\alpha \frac{1}{t}$$

10. For 4kg block

$4g\sin 60^0 - T = 4a$ …….(1)

$T - 1g\sin 30^0 = 1a$ …….(2)

From (1) and (2)

$$4g\frac{\sqrt{3}}{2} - T = 4T - 4g + \frac{1}{2}$$

$$2g\sqrt{3} - T = 4T - 2g$$

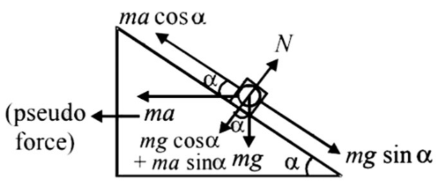
$$2g\sqrt{3} + 2g = 5T$$

$$20\sqrt{3} + 20 = 5T$$

$$T = \left(4\sqrt{3} + 4\right)N$$

11. When the incline is given an acceleration a towards the right the block experience a pseudo force ma towards left for block to remain stationary net force along the incline should be zero.

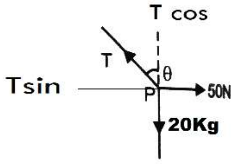
$$mg\sin\alpha = ma\cos\alpha$$



$$a = g\frac{\sin\alpha}{\cos\alpha}$$

$$a = g\tan\alpha$$

12. FBD of middle point is as shown



$T\sin\theta = 50$
$T\cos\theta = 200$
$\text{Tan}\,\theta = \frac{50}{200}$
$\text{Tan}\,\theta = \frac{5}{20}$
$\text{Tan}\,\theta = 0.25$
$\theta = \text{Tan}^{-1}(0.25)$
$\theta = \text{Tan}^{-1}(25\times10^{-2})$
$x = 25$

13. Tension =, $T = 360N$
Mass of a man $m = 60kg$
From FBD
$mg - T = ma\ \ a = g - \frac{T}{m}$
$a = 10 - \frac{360}{60}$
$a = \frac{600-36}{60}$
$a = \frac{240}{60} = 4m/\sec^2$

14. $m = 2kg$
$\frac{dm}{dt} = 1kg/\sec,$
$v = 5m/\sec$
$F = \frac{dp}{dt}$
$ma = \frac{dp}{dt} = V\frac{dm}{dt}$
$a = \frac{5}{2}\times1 = 2.5m/\sec^2$

15. Acceleration of system as
$a = \frac{6mg}{10m} = \frac{3g}{5}$
taking 8,9,10 together
$T = ma = 3m\times\frac{3g}{5}$
$T = \frac{3\times2\times3\times10}{5} = 36N$

16. By law of conservation of linear momentum $\vec{P}_i = \vec{P}_f$
$50\times v = (100+50)\times 4$

$50v = 150 \times 4$

$V = \frac{150 \times 4}{50} = 12m/\sec$

17. From the newton's second law

$F = \frac{dp}{dt} = \frac{d(mv)}{dt} = v\left(\frac{dm}{dt}\right)$ ……..(1)

We have given $\frac{dm(t)}{dt} = bv^2(t)$

Trust on the satellite,

$F = -V\left(\frac{dm}{dt}\right) = -v(bv^2) = -bv^3$

$F = m(t)a = -bv^3$

$a = \frac{-bv^3}{m(t)}$

18. Tension in the upper string

$T_1 = (m_1 + m_2)(g + a)$

$T_1 = (5+3)(9.8+2)$

$= 8 \times 11.8$

$T_1 = 94.4N$

Tension in the lower string

$T_2 = m_2(g + a)$

$= 3(9.8+2)$

$= 3(11.8)$

$T_2 = 35.4N$

19. From

$F = ma$

$ma = 10\cos 60$

$a = \frac{10\cos 60}{2+3}$

$a = \frac{10 \times \frac{1}{2}}{5} = 1m/\sec^2$

tension $T = ma = 2 \times 1 = 2N$

20. $F = \frac{dp}{dt} = \frac{d}{dt}\left[A\left(\hat{i}\cos kt - \hat{j}\sin kt\right)\right]$

$= -KA\left(\hat{i}\sin kt + \hat{j}\cos kt\right)$

$\vec{F}.\vec{P} = -KA\left(\hat{i}\sin kt + \hat{j}\cos kt\right).\left(a\hat{i}\cos kt - A\hat{j}\sin kt\right)$

$\vec{F}.\vec{P} = 0$

$\therefore$ angle between $\vec{F}$ and $\vec{P}$ is 90^0

21. $T = \frac{2m_1m_2g}{m_1+m_2}$

$T = \frac{2\times2\times M\times10}{2+M}$ as $M >> 2$

$T = \frac{2\times2\times M\times10}{M}$

$T = 40N$

22. $x^2 + y^2 = L^2$

Dff w.r.t time 't'

$2x\frac{dx}{dt} + 2y\frac{dy}{dt} = 0$

$u = -v\frac{y}{x}$

$= v\frac{y}{-x}$

$u = v\tan\theta \qquad \left(\tan\theta = \frac{OB}{OA}\right)$

23. Let m be the mass of rope and l its length. The tension T at a distance x from the support=weight of length (l-x) of the rope $= \frac{mg}{l}\times(l-x)$

$T = \frac{6\times10}{3}(3-1) = 40N$

24. For box : $T - R - mg = ma$ ……………(1)

For man $T + R - mg = ma$ …………….(2)

From (1) and (2)

$T = \frac{1}{2}(m+M)g + a$

putting $M = 2m$ and $a = \frac{g}{3}$

we get $T = \frac{2mg}{3}$

25. F-t graph=Area of EBCD

Area of trapezium EBCF+area of ΔCDF

$= \frac{1}{2}\times(200+800)N\times2\times10^{-3}S + \frac{1}{2}\times80N\times10\times10^{-3}s$

$= 1 + 4 = 5Ns$

26. When lifte is stationary $w_1 = mg$ …..(1)

When lift descends with acceleration a

$w_2 = m(g-a)$

$w_2 = \frac{100}{10}(10-5)$

$w_2 = 10(5) = 50N$

27. $m = 0.3kg$

$ma = -15x$

$0.3a = -15x$

$$a = \frac{15}{0.3}x = \frac{-150}{3}x = -50x$$

$$a = -50 \times 0.2 = 10m/\sec^2$$

28. $$F_x = \frac{dp_x}{dt} = 6t$$

$$F_y = \frac{dp_y}{dt} = 2t$$

at =1 sec

$Fx = 6 \qquad F_y = 2$

$$F = \sqrt{Fx^2 + F_y^2} = \sqrt{36+4} = \sqrt{40}, 2\sqrt{10}N$$

29. After throwing the ball $V = 0, s = 2m, a = -g$

$v^2 - u^2 = 2as$

$-u^2 = 2(-10) \times 2 \Rightarrow u^2 = 40$

When the ball is in the hand of the thrown

$u = 0, v = \sqrt{40}, s = 0.2m$

$v^2 - u^2 = 2as$

$40 - 0 = 2(a)(0.2)$

$a = 100m/\sec^2$

$F = ma = 0.2 \times 100 = 200N$

$N - mg = 20$

$N = 20 + mg$

$N = 0.2 \times 10 + 20 = 22N$

30. From FBD of B-lock

$F\cos 45^0 = mg\sin 45^0$

$$\frac{F}{mg} = \text{Tan}\,45^0$$

$$\frac{\sqrt{x}}{0.5 \times 10} = 1$$

$\sqrt{x} = 5$

$x = 25$