Conservation of Linear Momentum Impulse

1	b	2	b	3	b	4	c	5	c
6	a	7	a	8	c	9	b	10	c
11	c	12	a	13	a	14	b	15	c
16	c	17	a	18	c	19	c	20	c
21	d	22	c	23	a	24	d	25	d
26	b	27	c						

Equilibrium of Forces

1	d	2	c	3	b	4	a	5	c
6	c	7	b	8	b	9	b	10	c
11	d	12	a	13	a	14	a	15	a
16	b	17	b	18	b				

Motion of Connected Bodies

1	c	2	b	3	b	4	b	5	d
6	b	7	c	8	c	9	d	10	a
11	a	12	d	13	c	14	b	15	c
16	c	17	c	18	c	19	b	20	a
21	c	22	a	23	a				

Critical Thinking Questions

1	c	2	b	3	c	4	c	5	c
6	a	7	bc	8	d	9	c	10	b
11	a	12	d	13	c	14	d	15	b
16	c	17	c	18	c	19	d		

Graphical Questions

1	d	2	b	3	d	4	ac	5	c
6	d	7	b	8	c	9	d	10	c
11	c								

Assertion & Reason

1	e	2	c	3	a	4	b	5	c
6	a	7	c	8	a	9	d	10	c
11	c	12	b	13	d	14	a	15	c
16	e	17	a	18	a	19	b	20	c
21	e	22	d	23	b	24	e	25	e

AS Answers and Solutions

First Law of Motion

1. (c)
2. (c)
3. (d)
4. (b)
5. (b) Horizontal velocity of apple will remain same but due to retardation of train, velocity of train and hence velocity of boy *w.r.t.* ground decreases, so apple falls away from the hand of boy in the direction of motion of the train.
6. (c) Newton's first law of motion defines the inertia of body. It states that every body has a tendency to remain in its state (either rest or motion) due to its inerta.
7. (d) Horizontal velocity of ball and person are same so both will cover equal horizontal distance in a given interval of time and after following the parabolic path the ball falls exactly in the hand which threw it up.
8. (c) When the bird flies, it pushes air down to balance its weight. So the weight of the bird and closed cage assembly remains unchanged.
9. (d) Particle will move with uniform velocity due to inertia.
10. (a)
11. (b) When a sudden jerk is given to C, an impulsive tension exceeding the breaking tension develops in C first, which breaks before this impulse can reach A as a wave through block.
12. (a) When the spring C is stretched slowly, the tension in A is greater than that of C, because of the weight mg and the former reaches breaking point earlier.

Second Law of Motion

1. (b) $u = 100\ m/s,\ v = 0,\ s = 0.06\ m$

Retardation $= a = \frac{u^2}{2s} = \frac{(100)^2}{2 \times 0.06} = \frac{1 \times 10^6}{12}$

$\therefore$ Force $= ma = \frac{5 \times 10^{-3} \times 1 \times 10^6}{12} = \frac{5000}{12} = 417\ N$

2. (b) $\vec{F} = m\vec{a}$

3. (c) Acceleration $a = \frac{F}{m} = \frac{100}{5} = 20\ cm/s^2$

Now $v = at = 20 \times 10 = 200\ cm/s$

4. (b)

5. (b) $F = u\left(\frac{dm}{dt}\right) = 400 \times 0.05 = 20\ N$

6. (b) $u = 4\ m/s,\ v = 0,\ t = 2\sec$

$v = u + at \Rightarrow 0 = 4 + 2a \Rightarrow a = -2\ m/s^2$

$\therefore$ Retarding force $= ma = 2 \times 2 = 4\ N$

This force opposes the motion. If the same amount of force is applied in forward direction, then the body will move with constant velocity.

7. (d) Reading on the spring balance $= m\,(g - a)$ and since $a = g$ $\therefore$ Force = 0

8. (a) The lift is not accelerated, hence the reading of the balance will be equal to the true weight.

$R = mg = 2g$ *Newton* or $2\ kg$

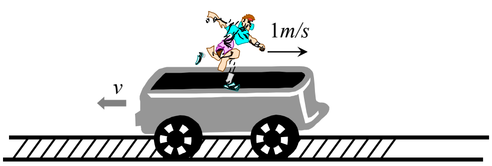
9. (d) When lift moves upward then reading of the spring balance, $R = m(g + a) = 2(g + g) = 4g\ N = 4\ kg$ [As $a = g$]

10. (a) For stationary lift $t_1 = \sqrt{\frac{2h}{g}}$

and when the lift is moving up with constant acceleration $t_2 = \sqrt{\frac{2h}{g+a}}$ $\therefore t_1 > t_2$

11. (d) Since $T = mg$, it implies that elevator may be at rest or in uniform motion.

12. (c) If the man starts walking on the trolley in the forward direction then whole system will move in backward direction with same momentum.



Momentum of man in forward direction = Momentum of system (man + trolley) in backward direction

$\Rightarrow 80 \times 1 = (80 + 320) \times v \Rightarrow v = 0.2\ m/s$

So the velocity of man *w.r.t.* ground $1.0 - 0.2 = 0.8\ m/s$

$\therefore$ Displacement of man *w.r.t.* ground $= 0.8 \times 4 = 3.2\ m$

13. (d) Force = Mass × Acceleration. If mass and acceleration both are doubled then force will become four times.

14. (b) As weight = 9.8 N $\therefore$ Mass = 1 kg

Acceleration $= \frac{\text{Force}}{\text{Mass}} = \frac{5}{1} = 5\ m/s^2$

15. (a) Force on the table = $mg = 40 \times 980 = 39200$ *dyne*

16. (b) $a = \frac{F}{m} = \frac{1\ N}{1\ kg} = 1\ m/s^2$

17. (b) $\vec{a} = \frac{\vec{v_2} - \vec{v_1}}{t} = \frac{(-2)-(+10)}{4} = \frac{-12}{4} = -3\ m/s^2$

18. (b) $F = ma = 10 \times (-3) = -30\ N$

19. (b) Impulse = Force × Time = $-30 \times 4 = -120\ N\text{-}s$

20. (b) u = velocity of bullet

$\frac{dm}{dt}$ = Mass thrown per second by the machine gun

= Mass of bullet × Number of bullet fired per second

$= 10\ g \times 10\ bullet/\sec = 100\ g/\sec = 0.1\ kg/\sec$

$\therefore$ Thrust $= \frac{udm}{dt} = 500 \times 0.1 = 50\ N$

21. (d) Acceleration of the car $= \frac{\text{Thrust on the car}}{\text{Mass of the car}}$

$= \frac{50}{2000} = \frac{1}{40} = 0.025\ m/s^2$

22. (b)

23. (b) Force on particle at 20 cm away $F = kx$

$F = 15 \times 0.2 = 3\ N$ [As $k = 15\ N/m$]

$\therefore$ Acceleration = $\frac{\text{Force}}{\text{Mass}} = \frac{3}{0.3} = 10\ m/s^2$

24. (a) Force on the block $F = u\left(\frac{dm}{dt}\right) = 5 \times 1 = 5\ N$

$\therefore$ Acceleration of block $a = \frac{F}{m} = \frac{5}{2} = 2.5\ m/s^2$

25. (a) Opposing force $F = u\left(\frac{dm}{dt}\right) = 2 \times 0.5 = 1\ N$

So same amount of force is required to keep the belt moving at 2 *m/s*

26. (d) Resultant force is $w + 3w = 4w$

27. (c) Acceleration $= \frac{\text{Force}}{\text{Mass}} = \frac{50\ N}{10\ kg} = 5\ m/s^2$

From $v = u + at = 0 + 5 \times 4 = 20\ m/s$

28. (c) Thrust $F = u\left(\frac{dm}{dt}\right) = 5 \times 10^4 \times 40 = 2 \times 10^6\ N$

29. (d) In stationary lift man weighs 40 *kg i.e.* 400 *N*.

When lift accelerates upward it's apparent weight $= m(g + a) = 40(10 + 2) = 480\ N$ *i.e.* 48 *kg*

For the clarity of concepts in this problem *kg-wt* can be used in place of *kg*.

30. (d) As the apparent weight increase therefore we can say that acceleration of the lift is in upward direction.

$R = m(g + a) \Rightarrow 4.8\ g = 4(g + a)$

$\Rightarrow a = 0.2g = 1.96\ m/s^2$

31. (d) $T = m(g + a) = 6000(10 + 5) = 90000\ N$

32. (a) $F = ma = \frac{m\Delta v}{\Delta t} = \frac{0.2 \times 20}{0.1} = 40\ N$

33. (a) $F = m\left(\frac{dv}{dt}\right) = \frac{100 \times 5}{0.1} = 5000\ N$

34. (d)

35. (b) $F = m(g + a) = 20 \times 10^3 \times (10 + 4) = 28 \times 10^4\ N$

36. (b) $\frac{mg}{m(g - a)} = \frac{3}{2} \Rightarrow a = g/3$

37. (a) $T = m(g + a) = 500(10 + 2) = 6000\ N$

38. (a) $F = u\left(\frac{dm}{dt}\right) \Rightarrow \frac{dm}{dt} = \frac{F}{u} = \frac{210}{300} = 0.7\ kg/s$

39. (d) $R = m(g + a) = m(g + g) = 2mg$

40. (a) $T_1 = m(g + a) = 1 \times \left(g + \frac{g}{2}\right) = \frac{3g}{2}$

$T_2 = m(g - a) = 1 \times \left(g - \frac{g}{2}\right) = \frac{g}{2}\ \therefore\ \frac{T_1}{T_2} = \frac{3}{1}$

41. (b) $F = \frac{udm}{dt} = m(g + a)$

$\Rightarrow \frac{dm}{dt} = \frac{m(g + a)}{u} = \frac{5000 \times (10 + 20)}{800} = 187.5\ kg/s$

$\left[\text{As, } F = u\frac{dm}{dt}\right]$

42. (c) Initially due to upward acceleration apparent weight of the body increases but then it decreases due to decrease in gravity.

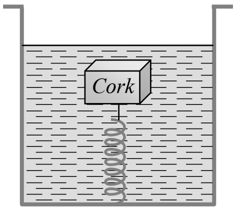
43. (b) $T = 2\pi\sqrt{\frac{l}{g}}$ and $T' = 2\pi\sqrt{\frac{l}{4g/3}}$

$\left[As\ g' = g + a = g + \frac{g}{3} = \frac{4g}{3}\right]$

$\therefore T' = \frac{\sqrt{3}}{2}T$

44. (b) Density of cork = *d*, Density of water = ρ

Resultant upward force on cork $= V(\rho - d)g$



This causes elongation in the spring. When the lift moves down with acceleration *a*, the resultant upward force on cork $= V(\rho - d)(g - a)$ which is less than the previous value. So the elongation decreases.

45. (d) When trolley are released then they posses same linear momentum but in opposite direction. Kinetic energy acquired by any trolley will dissipate against friction.

$\therefore\ \mu mgs = \frac{p^2}{2m} \Rightarrow s \propto \frac{1}{m^2}$ [As *P* and *u* are constants]

$\Rightarrow \frac{s_1}{s_2} = \left(\frac{m_2}{m_1}\right)^2 = \left(\frac{3}{1}\right)^2 = \frac{9}{1}$

46. (b) Apparent weight $= m(g - a) = 50(9.8 - 9.8) = 0$

47. (b) Opposite force causes retardation.

48. (a) $T = m(g - a) = 10(980 - 400) = 5800$ dyne

49. (d) $T = 2\pi\sqrt{\frac{l}{g}}$. *T* will decrease, If *g* increases.

It is possible when rocket moves up with uniform acceleration.

50. (c) We know that in the given condition $s \propto \frac{1}{m^2}$

$\therefore \frac{s_2}{s_1} = \left(\frac{m_1}{m_2}\right)^2 \Rightarrow s_2 = \left(\frac{m_1}{m_2}\right)^2 \times s_1$

51. (a) $m = \frac{F}{a} = \frac{\sqrt{6^2 + 8^2 + 10^2}}{1} = \sqrt{200} = 10\sqrt{2}\ kg$

52. (b) In the absence of external force, position of centre of mass remain same therefore they will meet at their centre of mass.

53. (d) Force
$$= m\left(\frac{dv}{dt}\right) = \frac{0.25\times[(10)-(-10)]}{0.01} = 25\times 20 = 500\ N$$

54. (d) $T = mg = 50\times 10^{-3}\times 10 = 0.5\ N$

55. (a) $F = u\left(\frac{dm}{dt}\right) = 20\times\frac{50}{60} = 16.66\ N$

56. (d) $u = 250\ m/s$, $v = 0$, $s = 0.12\ metre$
$$F = ma = m\left(\frac{u^2-v^2}{2s}\right) = \frac{20\times 10^{-3}\times(250)^2}{2\times 0.12}$$
$\therefore\quad F = 5.2\times 10^3\ N$

57. (a) $F = m\left(\frac{v-u}{t}\right) = \frac{5(65-15)\times 10^{-2}}{0.2} = 12.5\ N$

58. (d)

59. (c) $v = u + \frac{F}{m}t = 10 + \left(\frac{1000-500}{1000}\right)\times 10 = 15\ m/s$

60. (b) $F = ma = \frac{m(u-v)}{t} = \frac{2\times(8-0)}{4} = 4\ N$

61. (d) $R = m(g+a) = 10\times(9.8+2) = 118\ N$

62. (a) $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow \frac{T}{T} = \sqrt{\frac{g}{g}} = \sqrt{\frac{g}{g+\frac{g}{4}}} = \sqrt{\frac{4}{5}} = \frac{2}{\sqrt{5}}$

63. (d) $F = \frac{m(u^2-v^2)}{2S} = \frac{30\times 10^{-3}\times(120)^2}{2\times 12\times 10^{-2}} = 1800\ N$

64. (b) $dp = F\times dt = 10\times 10 = 100\ kg\ m/s$

65. (d) $R = m(g-a) = m(10-10) =$ zero

66. (b) Force exerted by the ball
$$\Rightarrow F = m\left(\frac{dv}{dt}\right) = 0.15\times\frac{20}{0.1} = 30\ N$$

67. (d) If rope of lift breaks suddenly, acceleration becomes equal to g so that tension, $T = m(g-g) = 0$

68. (d) $R = m(g+a) = 50\times(10+2) = 600\ N = 60\ kg\,wt$

69. (b) $F = u\left(\frac{dm}{dt}\right) = 500\times 50\times 10^{-3} = 25\ N$

70. (a) $S_{Horizontal} = ut = 1.5\times 4 = 6\ m$
$$S_{Vertical} = \frac{1}{2}at^2 = \frac{1}{2}\frac{F}{m}t^2 = \frac{1}{2}\times 1\times 16 = 8\ m$$
$$S_{Net} = \sqrt{6^2+8^2} = 10\ m$$

71. (c) $T = m(g+a) = 1000(9.8+1) = 10800\ N$

72. (d) The effective acceleration of ball observed by observer on earth = $(a - a_0)$

As $a_0 < a$, hence net acceleration is in downward direction.

73. (c) Due to relative motion, acceleration of ball observed by observer in lift = $(g - a)$ and for man on earth the acceleration remains g.

74. (c) For accelerated upward motion
$R = m(g+a) = 80(10+5) = 1200\ N$

75. (c) Tension the string $= m(g+a) =$ Breaking force
$\Rightarrow 20(g+a) = 25\times g \Rightarrow a = g/4 = 2.5\ m/s^2$

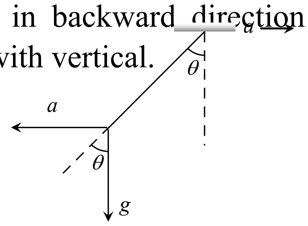
76. (b) Rate of flow will be more when lift will move in upward direction with some acceleration because the net downward pull will be more and vice-versa.
$F_{upward} = m(g+a)$ and $F_{downward} = m(g-a)$

77. (c) Initial thrust must be
$m[g+a] = 3.5\times 10^4(10+10) = 7\times 10^5\ N$

78. (b) When the lift is stationary $W = mg$
$\Rightarrow 49 = m\times 9.8 \Rightarrow m = 5\ kg.$

When the lift is moving downward with an acceleration $R = m(9.8-a) = 5[9.8-5] = 24\ N$

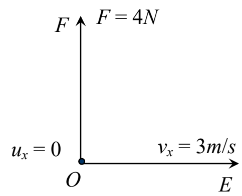
79. (a) When car moves towards right with acceleration a then due to pseudo force the plumb line will tilt in backward direction making an angle θ with vertical.



From the figure,
$\tan\theta = a/g$
$\therefore\ \theta = \tan^{-1}(a/g)$

80. (a) $R = m(g-a) = 0$

81. (b) Displacement of body in 4 sec along OE
$s_x = v_x t = 3\times 4 = 12\ m$



Force along OF (perpendicular to OE) = 4 N

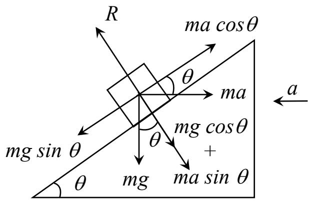
$\therefore\ a_y = \frac{F}{m} = \frac{4}{2} = 2\ m/s^2$

Displacement of body in 4 *sec* along *OF*

$\Rightarrow \quad s_y = u_y t + \frac{1}{2} a_y t^2 = \frac{1}{2} \times 2 \times (4)^2 = 16\ m$ [As $u_y = 0$]

$\therefore$ Net displacement $s = \sqrt{s_x^2 + s_y^2} = \sqrt{(12)^2 + (16)^2} = 20\ m$

82. (d)



When the whole system is accelerated towards left then pseudo force (ma) works on a block towards right.

For the condition of equilibrium

$mg\sin\theta = ma\cos\theta \Rightarrow a = \frac{g\sin\theta}{\cos\theta}$

$\therefore$ Force exerted by the wedge on the block R

$R = mg\cos\theta + ma\sin\theta$

$= mg\cos\theta + m\left(\frac{g\sin\theta}{\cos\theta}\right)\sin\theta = \frac{mg(\cos^2\theta + \sin^2\theta)}{\cos\theta}$

$R = \frac{mg}{\cos\theta}$

83. (d) u = velocity of bullet

$\frac{dm}{dt}$ = Mass fired per second by the gun

$\frac{dm}{dt}$ = Mass of bullet (m_B) × Bullets fired per sec (N)

Maximum force that man can exert $F = u\left(\frac{dm}{dt}\right)$

$\therefore \quad F = u \times m_B \times N$

$\Rightarrow N = \frac{F}{m_B \times u} = \frac{144}{40 \times 10^{-3} \times 1200} = 3$

84. (d) The stopping distance, $S \propto u^2$ $(\because v^2 = u^2 - 2as)$

$\Rightarrow \frac{S_2}{S_1} = \left(\frac{u_2}{u_1}\right)^2 = \left(\frac{120}{60}\right)^2 = 4$

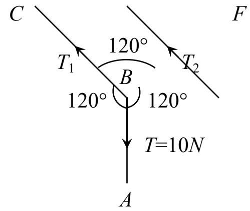
$\Rightarrow S_2 = 4 \times S_1 = 4 \times 20 = 80\ m$

85. (d) The apparent weight,

$R = m(g + a) = 75(10 + 5) = 1125\ N$

86. (c) By drawing the free body diagram of point B

Let the tension in the section BC and BF are T_1 and T_2 respectively.



From Lami's theorem

$\frac{T_1}{\sin 120°} = \frac{T_2}{\sin 120°} = \frac{T}{\sin 120°}$

$\Rightarrow T = T_1 = T_2 = 10\ N.$

87. (d) $F = \frac{dp}{dt} \equiv \frac{d}{dt}(a + bt^2) = 2bt \therefore \ F \propto t$

88. (a) When the lift moves upwards, the apparent weight,

$= m(g + a)$. Hence reading of spring balance increases.

89. (c) When lift is at rest, $T = 2\pi\sqrt{l/g}$

If acceleration becomes $g/4$ then

$T' = 2\pi\sqrt{\frac{l}{g/4}} = 2\pi\sqrt{\frac{4l}{g}} = 2 \times T$

90. (b) The apparent weight of man,

$R = m(g + a) = 80(10 + 6) = 1280\ N$

91. (b) $v = u + at = 0 + \left(\frac{F}{m}\right)t = \left(\frac{100}{5}\right) \times 10 = 200\ cm/\sec$

92. (b)

93. (a) $\Delta p = p_i - p_f = mv - (-mv) = 2mv$

94. (d) In the condition of free fall apparent weight becomes zero.

95. (a) Total mass of bullets = Nm, time $t = \frac{N}{n}$

Momentum of the bullets striking the wall = Nmv

Rate of change of momentum (Force) = $\frac{Nmv}{t} = nmv$.

96. (b)

97. (c) If man slides down with some acceleration then its apparent weight decreases. For critical condition rope can bear only 2/3 of his weight. If a is the minimum acceleration then,

Tension in the rope $= m(g - a)$ = Breaking strength

$\Rightarrow m(g - a) = \frac{2}{3}mg \Rightarrow a = g - \frac{2g}{3} = \frac{g}{3}$

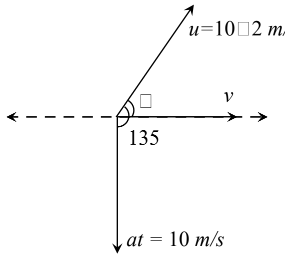
98. (a) For exerted by ball on wall

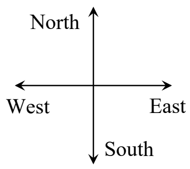
= rate of change in momentum of ball

$= \frac{mv - (-mv)}{t} = \frac{2mv}{t}$

99. (a) $\vec{v} = \vec{u} + \vec{a}t \therefore v = \sqrt{u^2 + a^2t^2 + 2uat\cos\theta}$

$$v = \sqrt{200 + 100 + 2 \times 10\sqrt{2} \times 10 \times \cos 135} = 10\, m/s$$





$$\tan\alpha = \frac{at\sin\theta}{u + at\cos\theta} \frac{10\sin 135}{10\sqrt{2} + 10\cos 135} = 1 \therefore \alpha = 45°$$

i.e. resultant velocity is 10 *m/s* towards East.

100. (c) $u_y = 40\, m/s,\ F_y = -5N,\ m = 5\, kg$.

So $a_y = \frac{F_y}{m} = -1\, m/s^2$ (As $v = u + at$)

$\therefore\ v_y = 40 - 1 \times t = 0 \Rightarrow t = 40\,\text{sec}$.

101. (a) Increment in kinetic energy = work done

$\Rightarrow \frac{1}{2}m(v^2 - u^2) = \int_{x_1}^{x_2} F.dx = \int_2^{10}(3x)\, dx$

$\Rightarrow \frac{1}{2}mv^2 = \frac{3}{2}[x^2]_2^{10} = \frac{3}{2}[100 - 4]$

$\Rightarrow \frac{1}{2} \times 8 \times v^2 = \frac{3}{2} \times 96 \Rightarrow v = 6\, m/s$

102. (c) $\vec{F} = \frac{d\vec{p}}{dt} = \frac{d}{dt}(a + bt^2) = 2bt$ *i.e.* $F \propto t$

103. (a) $F_{av} = \frac{\Delta p}{\Delta t} = \frac{mv - (-mv)}{\Delta t} = \frac{2mv}{\Delta t} = \frac{2 \times 0.5 \times 2}{10^{-3}} =$ 2000 *N*

104. (a) Given that $\vec{p} = p_x\hat{i} + p_y\hat{j} = 2\cos t\,\hat{i} + 2\sin t\,\hat{j}$

$\therefore\ \vec{F} = \frac{d\vec{p}}{dt} = -2\sin t\,\hat{i} + 2\cos t\,\hat{j}$

Now, $\vec{F}.\vec{p} = 0$ *i.e.* angle between $\vec{F}$ and $\vec{p}$ is 90°.

105. (b) $\vec{F} = \frac{d\vec{p}}{dt} =$ Rate of change of momentum

As balls collide elastically hence, rate of change of momentum of ball = $n[mu - (-mu)] = 2mnu$

i.e. $F = 2mnu$

106. (a) Velocity by which the ball hits the bat

$v_1 = \sqrt{2gh_1} = \sqrt{2 \times 10 \times 5}$ or $\vec{v}_1 = +10\, m/s = 10\, m/s$

velocity of rebound

$v_2 = \sqrt{2gh_2} = \sqrt{2 \times 10 \times 20} = 20\, m/s$ or $\vec{v}_2 = -20\, m/s$

$$F = m\frac{dv}{dt} = \frac{m(\vec{v}_2 - \vec{v}_1)}{dt} = \frac{0.4(-20 - 10)}{dt} = 100\, N$$

by solving $dt = 0.12\,\text{sec}$

107. (a) $\vec{F} = \frac{\Delta\vec{p}}{\Delta t} \Rightarrow \Delta t = \frac{|\Delta\vec{p}|}{|\vec{F}|} = \frac{0.4}{2} = 0.2\, s$

108. (c) Rate of change of momentum of the bullet in forward direction = Force required to hold the gun.

$F = nmv = 4 \times 20 \times 10^{-3} \times 300 = 24\, N$

109. (d) Rate of flow of water $\frac{V}{t} = \frac{10\, cm^3}{\text{sec}} = 10 \times 10^{-6}\, \frac{m^3}{\text{sec}}$

Density of water $\rho = \frac{10^3\, kg}{m^3}$

Cross-sectional area of pipe $A = \pi(0.5 \times 10^{-3})^2$

$$\text{Force} = m\frac{dv}{dt} = \frac{mv}{t} = \frac{V\rho v}{t} = \frac{\rho V}{t} \times \frac{V}{At} = \left(\frac{V}{t}\right)^2 \frac{\rho}{A}$$

$$\left(\because v = \frac{V}{At}\right)$$

By substituting the value in the above formula we get

$F = 0.127\, N$

110. (a) Weight of the disc will be balanced by the force applied by the bullet on the disc in vertically upward direction.

$F = nmv = 40 \times 0.05 \times 6 = Mg$

$\Rightarrow M = \frac{40 \times 0.05 \times 6}{10} = 1.2\, kg$

111. (a)

112. (c) $F = \frac{dp}{dt} = v\left(\frac{dM}{dt}\right) = \alpha v^2 \therefore a = \frac{F}{M} = \frac{\alpha v^2}{M}$

113. (d) $P = \frac{F}{A} = \frac{n[mv - (-mv)]}{A} = \frac{2mnv}{A}$

$$= \frac{2 \times 10^{-3} \times 10^4 \times 10^2}{10^{-4}} = 2 \times 10^7\, N/m^2$$

Third Law of Motion

1. (c) Swimming is a result of pushing water in the opposite direction of the motion.

2. (b) Because for every action there is an equal and opposite reaction takes place.

3. (b)

4. (a) The force exerted by the air of fan on the boat is internal and for motion external force is required.

5. (c)
6. (c)
7. (a) Up thrust on the body $= v\sigma g$. For freely falling body effective *g* becomes zero. So up thrust becomes zero
8. (d)
9. (c) Total weight in right hand = 10 + 1 = 1 *kg*
10. (c)
11. (a) For jumping he presses the spring platform, so the reading of spring balance increases first and finally it becomes zero.
12. (c) Gas will come out with sufficient speed in forward direction, so reaction of this forward force will change the reading of the spring balance.
13. (b)
14. (b) Since the cage is closed and we can treat bird, cage and the air as a closed (isolated) system. In this condition the force applied by the bird on cage is an internal force, due to this the reading of spring balance will not change.
15. (b) As the spring balance are massless therefore both the scales read *M kg* each.
16. (d) $F = mnv = 150 \times 10^{-3} \times 20 \times 800 = 2400\ N.$
17. (c) 5*N* force will not produce any tension in spring without support of other 5*N* force. So here the tension in the spring will be 5*N* only.
18. (d) Since action and reaction acts in opposite direction on same line, hence angle between them is 180°.
19. (a)
20. (d) As by an internal force momentum of the system can not be changed.
21. (b)
22. (b) Since downward force along the inclined plane

$= mg\sin\theta = 5 \times 10 \times \sin 30° = 25\,N$

23. (c) At 11th second lift is moving upward with acceleration

$$a = \frac{0 - 3.6}{2} = -1.8\,m/s^2$$

Tension in rope, $T = m(g - a)$

$= 1500(9.8 - 1.8) = 12000\,N$

24. (d) Distance travelled by the lift

= Area under velocity time graph

$$= \left(\frac{1}{2} \times 2 \times 3.6\right) + (8 \times 3.6) + \left(\frac{1}{2} \times 2 \times 3.6\right) = 36\,m$$

Conservation of Linear Momentum and Impulse

1. (b)
2. (b) Force exerted by the ball on hands of the player

$$= \frac{mdv}{dt} = \frac{0.15 \times 20}{0.1} = 30\ N$$

3. (b) $F = u\left(\frac{dm}{dt}\right) = 500 \times 1 = 500\ N$
4. (c) If momentum remains constant then force will be zero because $F = \frac{dP}{dt}$
5. (c) According to principle of conservation of linear momentum $1000 \times 50 = 1250 \times v \Rightarrow v = 40\,km/hr$
6. (a) Change in momentum = Impulse

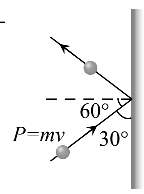
$$\Rightarrow \Delta p = F \times \Delta t \Rightarrow \Delta t = \frac{\Delta p}{F} = \frac{125}{250} = 0.5 \text{ sec}$$

7. (a) During collision of ball with the wall horizontal momentum changes (vertical momentum remains constant)

$$\therefore F = \frac{\text{Change in horizontal momentum}}{\text{Time of contact}}$$

$$= \frac{2P\cos\theta}{0.1} = \frac{2mv\cos\theta}{0.1}$$

$$= \frac{2 \times 0.1 \times 10 \times \cos 60°}{0.1} = 10\ N$$



8. (c) Impulse = Force × time = *m a t*

$= 0.15 \times 20 \times 0.1 = 0.3\ N\text{-}s$

9. (b) For a given mass $P \propto v$. If the momentum is constant then it's velocity must have constant.
10. (c)
11. (c) $T = \frac{F(L - x)}{L} = \frac{5(5 - 1)}{5} = 4\,N$
12. (a)
13. (a) $F = u\left(\frac{dm}{dt}\right) = 3000 \times 4 = 12000\ N$

14. (b)

15. (c) It works on the principle of conservation of momentum.

16. (c) $v_G = \frac{m_B v_B}{m_G} = \frac{0.2 \times 5}{1} = 1\ m/s$

17. (a) By the conservation of linear momentum $m_B v_B = m_a v_a$

$$\Rightarrow v_G = \frac{m_B \times v_B}{m_G} = \frac{5 \times 10^{-3} \times 500}{5} = 0.5\ m/s$$

18. (c) Impulse, $I = F \times \Delta t = 50 \times 10^{-5} \times 3 = 1.5 \times 10^{-3}\ N\text{-}s$

19. (c) Momentum of one piece $= \frac{M}{4} \times 3$

Momentum of the other piece $= \frac{M}{4} \times 4$

$\therefore$ Resultant momentum $= \sqrt{\frac{9M^2}{16} + M^2} = \frac{5M}{4}$

The third piece should also have the same momentum. Let its velocity be v, then

$\frac{5M}{4} = \frac{M}{2} \times v$ or $v = \frac{5}{2} = 2.5\ m/sec$

20. (c)

21. (d) Using law of conservation of momentum, we get

$100 \times v = 0.25 \times 100 \Rightarrow v = 0.25\ m/s$

22. (c) $F = 600 - 2 \times 10^5 t = 0 \Rightarrow t = 3 \times 10^{-3}$ sec

Impulse $I = \int_0^t F\,dt = \int_0^{3 \times 10^{-3}} (600 - 2 \times 10^3 t)dt$

$= [600t - 10^5 t^2]_0^{3 \times 10^{-3}} = 0.9\ N \times \text{sec}$

23. (a) According to principle of conservation of linear momentum, $m_G v_G = m_B v_B$

$$\Rightarrow v_G = \frac{m_B v_B}{m_G} = \frac{0.1 \times 10^2}{50} = 0.2 m/s$$

24. (d) $m_G v_G = m_B v_B \Rightarrow v_B = \frac{m_G v_G}{m_B} = \frac{1 \times 5}{10 \times 10^{-3}} = 500 m/s$

25. (d)

26. (b) The acceleration of a rocket is given by

$$a = \frac{v}{m}\left(\frac{\Delta m}{\Delta t}\right) - g = \frac{400}{100}\left(\frac{5}{1}\right) - 10$$

$= (20 - 10) = 10\ m/s^2$

27. (c)

Equilibrium of Forces

1. (d) Application of Bernoulli's theorem.

2. (c)

3. (b) $F = \sqrt{(F)^2 + (F)^2 + 2F.F\cos\theta} \Rightarrow \theta = 120°$

4. (a) $F_{net}^2 = F_1^2 + F_2^2 + 2F_1F_2\cos\theta$

$$\Rightarrow \left(\frac{F}{3}\right)^2 = F^2 + F^2 + 2F^2\cos\theta \Rightarrow \cos\theta = \left(-\frac{17}{18}\right)$$

5. (c) Direction of second force should be at 180°.

6. (c) $F_{max} = 5 + 10 = 15N$ and $F_{min} = 10 - 5 = 5N$

Range of resultant $5 \le F \le 15$

7. (b) $R^2 = (3P)^2 + (2P)^2 + 2 \times 3P \times 2P \times \cos\theta$ ...(i)

$(2R)^2 = (6P)^2 + (2P)^2 + 2 \times 6P \times 2P \times \cos\theta$ ...(ii)

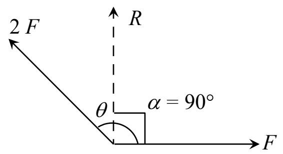
by solving (i) and (ii), $\cos\theta = -1/2 \Rightarrow \theta = 120°$

8. (b) $\tan\alpha = \frac{2F\sin\theta}{F + 2F\cos\theta} = \infty$ (as α = 90°)

$\Rightarrow F + 2F\cos\theta = 0$

$\Rightarrow \cos\theta = -\frac{1}{2}$

$\theta = 120°$



9. (b) $A + B = 18$ ...(i)

$12 = \sqrt{A^2 + B^2 + 2AB\cos\theta}$ ...(ii)

$\tan\alpha = \frac{B\sin\theta}{A + B\cos\theta} = \tan 90° \Rightarrow \cos\theta = -\frac{A}{B}$ ...(iii)

By solving (i), (ii) and (iii), $A = 13N$ and $B = 5N$

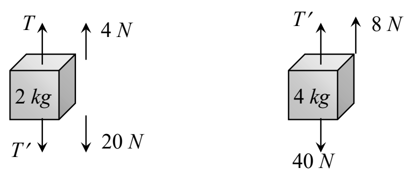
10. (c)

11. (d) Range of resultant of F_1 and F_2 varies between (3+5)=8N and $(5 - 3) = 2N$. It means for some value of angle (θ), resultant 6 can be obtained. So, the resultant of 3N, 5N and 6N may be zero and the forces may be in equilibrium.

12. (a) Net force on the particle is zero so the $\vec{v}$ remains unchanged.

13. (a) For equilibrium of forces, the resultant of two (smaller) forces should be equal and opposite to third one.

14. (a) FBD of mass 2 *kg* FBD of mass 4*kg*



$T - T' - 20 = 4$ ....(i) $T' - 40 = 8$ ...(ii)

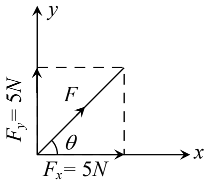
By solving (i) and (ii) $T' = 47.23\ N$ and $T = 70.8\ N$

15. (a)

16. (b) $|\vec{F}| = \sqrt{5^2 + 5^2} = 5\sqrt{2}\ N.$

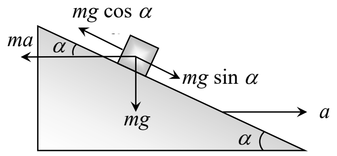
and $\tan\theta = \frac{5}{5} = 1$

$\Rightarrow \theta = \pi/4.$



17. (b)

18. (b)

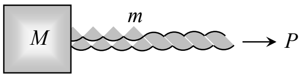


Let the mass of a block is *m*. It will remains stationary if forces acting on it are in equilibrium *i.e,* $ma\cos\alpha = mg\sin\alpha \Rightarrow a = g\tan\alpha$

Here ma = Pseudo force on block, *mg* = Weight.

Motion of Connected Bodies

1. (c)

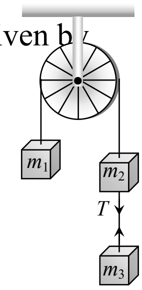


Acceleration of the system $= \frac{P}{m+M}$

The force exerted by rope on the mass $= \frac{MP}{m+M}$

2. (b)

3. (b) Tension between m_2 and m_3 is given by



$T = \frac{2m_1 m_3}{m_1 + m_2 + m_3} \times g$

$= \frac{2\times2\times2}{2+2+2} \times 9.8 = 13\ N$

4. (b) $a = \frac{m_2}{m_1 + m_2} \times g = \frac{5}{4+5} \times 9.8 = \frac{49}{9} = 5.44\ m/s^2$

5. (d) $T = \frac{2m_1 m_2}{m_1 + m_2} g = \frac{2\times2\times3}{2+3} g = \frac{12}{5} g$

$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right) g = \left(\frac{3-2}{3+2}\right) g = \frac{g}{5}$

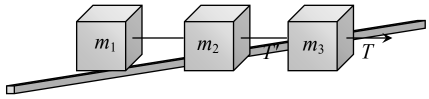
6. (b) $T_2 = (m_A + m_B) \times \frac{T_3}{m_A + m_B + m_C}$

$T_2 = (1+8) \times \frac{36}{(1+8+27)} = 9\ N$

7. (c) Acceleration $= \frac{(m_2 - m_1)}{(m_2 + m_1)} g$

$= \frac{4-3}{4+3} \times 9.8 = \frac{9.8}{7} = 1.4\ m/sec^2$

8. (c)



$T' = (m_1 + m_2) \times \frac{T}{m_1 + m_2 + m_3}$

9. (d) $T_2 = (m_1 + m_2) \times \frac{T_3}{m_1 + m_2 + m_3} = \frac{(10+6)\times 40}{20} = 32\ N$

10. (a)

11. (a) Acceleration $= \frac{m_2}{m_1 + m_2} \times g$

$= \frac{1}{2+1} \times 9.8 = 3.27\ m/s^2$

and $T = m_1 a = 2 \times 3.27 = 6.54\ N$

12. (d) $T = \frac{2m_1 m_2}{m_1 + m_2} g = \frac{2\times10\times6}{10+6} \times 9.8 = 73.5\ N$

13. (c) $a = \frac{m_2 - m_1}{m_1 + m_2} g = \frac{10-5}{10+5} g = \frac{g}{3}$

14. (b) $a = \frac{m_2}{m_1 + m_2} g = \frac{3}{7+3} 10 = 3\ m/s^2$

15. (c) $T_1 = \left(\frac{m_2 + m_3}{m_1 + m_2 + m_3}\right) g = \frac{3+5}{2+3+5} \times 10 = 8\ N$

16. (c) $a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right) g = \left(\frac{10-6}{10+6}\right) \times 10 = 2.5\ m/s^2$

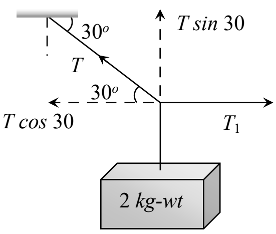
17. (c) $T\sin 30 = 2 kg\,wt$

$\Rightarrow T = 4\ kg\,wt$

$T_1 = T\cos 30°$

$= 4\cos 30°$

$= 2\sqrt{3}$



18. (c) If monkey move downward with acceleration *a* then its apparent weight decreases. In that condition

Tension in string $= m(g - a)$

This should not be exceed over breaking

strength of the rope *i.e.* $360 \geq m(g-a) \Rightarrow 360 \geq 60(10-a)$

$\Rightarrow a \geq 4\ m/s^2$

19. (b) $a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g \Rightarrow \frac{g}{8} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g \Rightarrow \frac{m_1}{m_2} = \frac{9}{7}$

20. (a) $a = \left[\frac{m_1 - m_2}{m_1 + m_2}\right] g = \left[\frac{5 - 4.8}{5 + 4.8}\right] \times 9.8 = 0.2\ m/s^2$

21. (c) As the spring balances are massless therefore the reading of both balance should be equal.

22. (a) $a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right) g = \left(\frac{m - m/2}{m + m/2}\right) g = \frac{g}{3}$

23. (a) Acceleration of each mass $= a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$

Now acceleration of centre of mass of the system

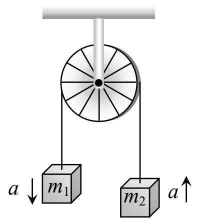
$$A_{cm} = \frac{m_1 \vec{a_1} + m_1 \vec{a_2}}{m_1 + m_2}$$

As both masses move with same acceleration but in opposite direction so $\vec{a_1} = -\vec{a_2} = a$ (let)

$$\therefore A_{cm} = \frac{m_1 a - m_2 a}{m_1 + m_2}$$

$$= \left(\frac{m_1 - m_2}{m_1 + m_2}\right) \times \left(\frac{m_1 - m_2}{m_1 + m_2}\right) \times g$$

$$= \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 \times g$$



Critical Thinking Questions

1. (c) Due to acceleration in forward direction, vessel is an accelerated frame therefore a Pseudo force will be exerted in backward direction. Therefore water will be displaced in backward direction.

2. (b) The pressure on the rear side would be more due to fictitious force (acting in the opposite direction of acceleration) on the rear face. Consequently the pressure in the front side would be lowered.

3. (c) $v^2 = 2as = 2\left(\frac{F}{m}\right)s$ $\quad [As\ u = 0]$

$\Rightarrow v^2 = 2\left(\frac{5 \times 10^4}{3 \times 10^7}\right) \times 3 = \frac{1}{100}$

$\Rightarrow v = 0.1\ m/s$

4. (c) Mass measured by physical balance remains unaffected due to variation in acceleration due to gravity.

5. (c) For W, $2W$, $3W$ apparent weight will be zero because the system is falling freely. So the distances of the weight from the rod will be same.

6. (a) For equilibrium of system, $F_1 = \sqrt{F_2^2 + F_3^2}$ As $\theta = 90°$

In the absence of force F_1, Acceleration $= \frac{\text{Net force}}{\text{Mass}}$

$$= \frac{\sqrt{F_2^2 + F_3^2}}{m} = \frac{F_1}{m}$$

7. (b,c) Force of upthrust will be there on mass m shown in figure, so A weighs less than 2 kg. Balance will show sum of load of beaker and reaction of upthrust so it reads more than 5 kg.

8. (d) Heavier gas will acquire largest momentum *i.e.* Argon.

9. (c) $\vec{F}\Delta t = m\Delta\vec{v} \Rightarrow F = \frac{m\Delta\vec{v}}{t}$

By doing so time of change in momentum increases and impulsive force on knees decreases.

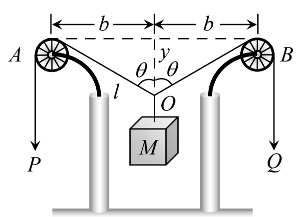
10. (b) When false balance has equal arms then, $W = \frac{X + Y}{2}$

11. (a) Let two vectors be $\vec{A}$ and $\vec{B}$ then $(\vec{A} + \vec{B}).(\vec{A} - \vec{B}) = 0$

$$\vec{A}.\vec{A} - \vec{B}.\vec{B} + \vec{B}.\vec{A} - \vec{B}.\vec{B} = 0$$

$$A^2 - B^2 = 0 \Rightarrow A^2 = B^2 \therefore A = B$$

12. (d)



As P and Q fall down, the length l decreases at the rate of U m/s.

From the figure, $l^2 = b^2 + y^2$

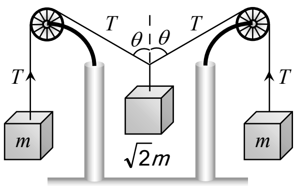
Differentiating with respect to time

$$2l \times \frac{dl}{dt} = 2b \times \frac{db}{dt} + 2y \times \frac{dy}{dt} \left(\text{As } \frac{db}{dt} = 0, \frac{dl}{dt} = U\right)$$

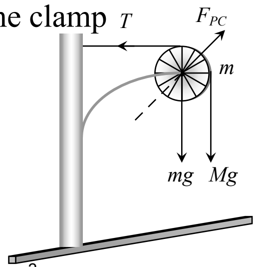
$$\Rightarrow \frac{dy}{dt} = \left(\frac{l}{y}\right) \times \frac{dl}{dt} \Rightarrow \frac{dy}{dt} = \left(\frac{1}{\cos\theta}\right) \times U = \frac{U}{\cos\theta}$$

13. (c) From the figure for the equilibrium of the system

$$2T\cos\theta = \sqrt{2}mg \Rightarrow \cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45°$$



14. (d) Force on the pulley by the clamp



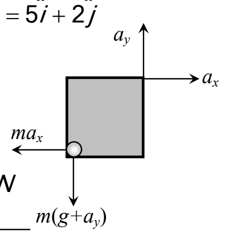
$$F_{pc} = \sqrt{T^2 + [(M+m)g]^2}$$

$$F_{pc} = \sqrt{(Mg)^2 + [(M+m)g]^2}$$

$$F_{pc} = \sqrt{M^2 + (M+m)^2}\, g$$

15. (b) $a_{cm} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 g = \left(\frac{3m - m}{3m + m}\right)^2 g = \frac{g}{4}$

16. (c) As $\vec{v} = 5t\hat{i} + 2t\hat{j}$ $\therefore$ $\vec{a} = a_x\hat{i} + a_y\hat{j} = 5\hat{i} + 2\hat{j}$



$$\vec{F} = ma_x\hat{i} + m(g + a_y)\hat{j}$$

$$\therefore |\vec{F}| = m\sqrt{a_x^2 + (g + a_y)^2} = 26\ N$$

17. (c) $l = l_0\sqrt{1 - \frac{v^2}{c^2}} = 1\sqrt{1 - \left(\frac{2.7 \times 10^8}{3 \times 10^8}\right)^2} \Rightarrow l = 0.44\ m$

18. (c) $T = \frac{T_0}{[1 - (v^2/c^2)]^{1/2}}$

By substituting $T_0 = 1$ day and $T = 2$ days we get

$v = 2.6 \times 10^8\ ms^{-1}$

19. (d) Force acting on plate, $F = \frac{dp}{dt} = v\left(\frac{dm}{dt}\right)$

Mass of water reaching the plate per *sec* = $\frac{dm}{dt}$

$$= Av\rho = A(v_1 + v_2)\rho = \frac{V}{v_2}(v_1 + v_2)\rho$$

($v = v_1 + v_2 =$ velocity of water coming out of jet *w.r.t.* plate)

($A =$ Area of cross section of jet $= \frac{V}{v_2}$)

$$\therefore F = \frac{dm}{dt}v = \frac{V}{v_2}(v_1 + v_2)\rho \times (v_1 + v_2) = \rho\left[\frac{V}{v_2}\right](v_1 + v_2)^2$$

Graphical Questions

1. (d) If the applied force is less than limiting friction between block A and B, then whole system move with common acceleration

i.e. $a_A = a_B = \frac{F}{m_A + m_B}$

But the applied force increases with time, so when it becomes more than limiting friction between A and B, block B starts moving under the effect of net force $F - F_k$

Where $F_k =$ Kinetic friction between block A and B

$\therefore$ Acceleration of block B, $a_B = \frac{F - F_k}{m_B}$

As F is increasing with time so a_B will increase with time

Kinetic friction is the cause of motion of block A

$\therefore$ Acceleration of block A, $a_A = \frac{F_k}{m_A}$

It is clear that $a_B > a_A$. *i.e.* graph (d) correctly represents the variation in acceleration with time for block A and B.

2. (b) Velocity between $t = 0$ and $t = 2\,\text{sec}$

$$\Rightarrow v_i = \frac{dx}{dt} = \frac{4}{2} = 2\ m/s$$

Velocity at $t = 2\,\text{sec}$, $v_f = 0$

Impulse = Change in momentum $= m(v_f - v_i)$

$= 0.1(0 - 2) = -0.2\ kg\,m\,\text{sec}^{-1}$

3. (d) Momentum acquired by the particle is numerically equal to area enclosed between the *F-t* curve and time axis. For the given diagram area in upper half is positive and in lower half is negative (and equal to upper half), so net area is zero. Hence the momentum acquired by the particle will be zero.

4. (a,c) In region *AB* and *CD*, slope of the graph is constant *i.e.* velocity is constant. It means no force acting on the

5. (c) Impulse = Change in momentum $= m(v_2 - v_1)$ …(i)

   Again impulse = Area between the graph and time axis

   $= \frac{1}{2}\times 2\times 4 + 2\times 4 + \frac{1}{2}(4+2.5)\times 0.5 + 2\times 2.5$

   $= 4 + 8 + 1.625 + 5 \ = 18.625$ ...(ii)

   From (i) and (ii), $m(v_2 - v_1) = 18.625$

   $\Rightarrow v_2 = \frac{18.625}{m} + v_1 = \frac{18.625}{2} + 5 = 14.25\ m/s$

6. (d) $K = \frac{F}{x}$ and increment in length is proportional the original length *i.e.* $x \propto l$ $\therefore$ $K \propto \frac{1}{l}$

   It means graph between *K* and *l* should be hyperbolic in nature.

7. (b) In elastic one dimensional collision particle rebounds with same speed in opposite direction

   i.e. change in momentum $= 2mu$

   But Impulse $= F \times T =$ Change in momentum

   $\Rightarrow F_0 \times T = 2mu \Rightarrow F_0 = \frac{2mu}{T}$

8. (c) Initially particle was at rest. By the application of force its momentum increases.

   Final momentum of the particle $=$ Area of *F* - *t* graph

   $\Rightarrow mu =$ Area of semi circle

   $mu = \frac{\pi r^2}{2} = \frac{\pi r_1 r_2}{2} = \frac{\pi (F_0)(T/2)}{2} \Rightarrow u = \frac{\pi F_0 T}{4m}$

9. (d) momentum acquired = Area of force-time graph

   $= \frac{1}{2}\times(2)\times(10) + 4\times 10 = 10 + 40 = 50\ N\text{-}S$

10. (c) $F = \frac{dp}{dt}$, so the force is maximum when slope of graph is maximum

11. (c) Impulse = Area between force and time graph and it is maximum for graph (III) and (IV)

Assertion and Reason

1. (e) Inertia is the property by virtue of which the body is unable to change by itself not only the state of rest, but also the state of motion.

2. (c) According to Newton's second law

   Acceleration $= \frac{\text{Force}}{\text{Mass}}$ *i.e.* if net external force on the body is zero then acceleration will be zero

3. (a) According to second law $F = \frac{dp}{dt} = ma$.

   If we know the values of *m* and *a*, the force acting on the body can be calculated and hence second law gives that how much force is applied on the body.

4. (b) When a body is moving in a circle, its speed remains same but velocity changes due to change in the direction of motion of body. According to first law of motion, force is required to change the state of a body. As in circular motion the direction of velocity of body is changing so the acceleration cannot be zero. But for a uniform motion acceleration is zero (for rectilinear motion).

5. (c) According to definition of momentum

   $P = mv$ if *P* = constant then $mv =$ constant or $v \propto \frac{1}{m}$.

   As velocity is inversely proportional to mass, therefore lighter body possess greater velocity.

6. (a) The wings of the aeroplane pushes the external air backward and the aeroplane move forward by reaction of pushed air. At low altitudes. density of air is high and so

the aeroplane gets sufficient force to move forward.

7. (c) Force is required to change the state of the body. In uniform motion body moves with constant speed so acceleration should be zero.

8. (a) According to Newton's second law of motion $a = \frac{F}{m}$ *i.e.* magnitude of the acceleration produced by a given force is inversely proportional to the mass of the body. Higher is the mass of the body, lesser will be the acceleration produced *i.e.* mass of the body is a measure of the opposition offered by the body to change a state, when the force is applied *i.e.* mass of a body is the measure of its inertia.

9. (d) $F = \frac{dp}{dt}$ = Slope of momentum-time graph

i.e. Rate of change of momentum = Slope of momentum- time graph = force.

10. (c) The purpose of bending is to acquire centripetal force for circular motion. By doing so component of normal reaction will counter balance the centrifugal force.

11. (c) Work done in moving an object against gravitational force (conservative force) depends only on the initial and final position of the object, not upon the path taken. But gravitational force on the body along the inclined plane is not same as that along the vertical and it varies with the angle of inclination.

12. (b) In uniform circular motion of a body the speed remains constant but velocity changes as direction of motion changes.

As linear momentum = mass × velocity, therefore linear momentum of a body changes in a circle.

On the other hand, if the body is moving uniformly along a straight line then its velocity remains constant and hence acceleration is equal to zero. So force is equal to zero.

13. (d) Law of conservation of linear momentum is correct when no external force acts . When bullet is fired from a rifle then both should possess equal momentum but different kinetic energy. E $= \frac{P^2}{2m}$ $\therefore$ Kinetic energy of the rifle is less than that of bullet because $E \propto 1/m$

14. (a) As the fuel in rocket undergoes combustion, the gases so produced leave the body of the rocket with large velocity and give upthrust to the rocket. If we assume that the fuel is burnt at a constant rate, then the rate of change of momentum of the rocket will be constant. As more and more fuel gets burnt, the mass of the rocket goes on decreasing and it leads to increase of the velocity of rocket more and more rapidly.

15. (c) The apparent weight of a body in an elevator moving with downward acceleration *a* is given by $W = m(g - a)$.

16. (e) For uniform motion apparent weight = Actual weight

For downward accelerated motion,

Apparent weight < Actual weight

17. (a)

18. (a) By lowering his hand player increases the time of catch, by doing so he experience less force on his hand because $F \propto 1/dt$.

19. (b) According to Newton's second law,

$F = ma \Rightarrow a = F/m$

For constant *F*, acceleration is inversely proportional to mass *i.e.* acceleration produced by a force depends only upon the mass of the body and for larger mass acceleration will be less.

20. (c) In uniform circular motion, the direction of motion changes, therefore velocity changes.

As $P = mv$ therefore momentum of a body also changes in uniform circular motion.

21. (e) According to third law of motion it is impossible to have a single force out of mutual interaction between two bodies, whether they are moving or at rest. While,

Newton’s third law is applicable for all types of forces.

22. (d) An inertial frame of reference is one which has zero acceleration and in which law of inertia hold good i.e. Newton’s law of motion are applicable equally. Since earth is revolving around the sun and earth is rotating about its own axis also, the forces are acting on the earth and hence there will be acceleration of earth due to these factors. That is why earth cannot be taken as inertial frame of reference.

23. (b) According to law of inertia (Newton’s first law), when cloth is pulled from a table, the cloth come in state of motion but dishes remains stationary due to inertia. Therefore when we pull the cloth from table the dishes remains stationary.

24. (e) A body subjected to three concurrent forces is found to in equilibrium if sum of these force is equal to zero.

i.e. $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + ... = 0.$

25. (e) From Newton's second law

Impulse = Change of momentum.

So they have equal dimensions