# Physicsaholics

**DPP – 7 (COM)**

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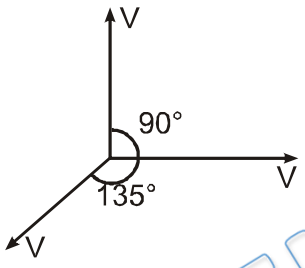
Q 1. A particle of mass 4 m which is at rest explodes into four equal fragments. All 4 fragments scattered in the same horizontal plane. Three fragments are found to move with velocity V each as shown in the figure. The total energy released in the process of explosion is :

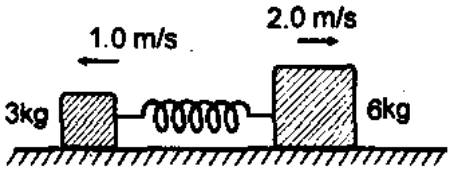



(a) $mV^2\left(\mathbf{3}-\sqrt{\mathbf{2}}\right)$ (b) $2\ mV^2$ (c) $mV^2\frac{(3-\sqrt{2})}{2}$ (d) $mV^2\frac{(1+\sqrt{2})}{2}$

Q 2. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 $ms^{-1}$. The kinetic energy of the other mass is :

(a) 256 J (b) 486 J (c) 524 J (d) 324 J

Q 3. Two blocks of mass 3kg and 6 kg respectively are placed on a smooth horizontal surface. They are connected by a light spring of force constant k = 200 N/m. Initially the spring is unstretched. The indicated velocities are imparted to the blocks. The maximum extension of the spring will be:




(a) 30 cm (b) 25 cm (c) 20 cm (d) 15 cm

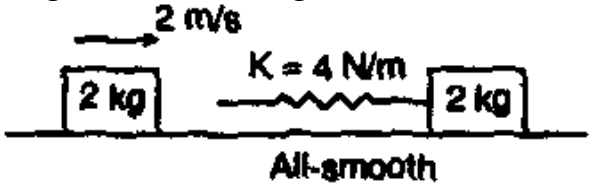
Q 4. Two blocks A and B of mass m and 2m are connected by a massless spring of force constant k. They are placed on a smooth horizontal plane. Spring is stretched by an amount x and then released. The relative velocity of the blocks when the spring comes to its natural length is


(a) $\left(\sqrt{\frac{3k}{2m}}\right)x$ (b) $\left(\sqrt{\frac{2k}{3m}}\right)x$ (c) $\sqrt{\frac{2kx}{m}}$ (d) $\sqrt{\frac{3kx}{2m}}$

Q 5. An isolated particle of mass m is moving in horizontal plane (x-y), along the x-axis, at a certain height above the ground. It suddenly explodes into two fragments of masses m/4 and 3m/4. An Instant later, the smaller fragment is at y = + 15 cm. The larger fragment at this instant is at:

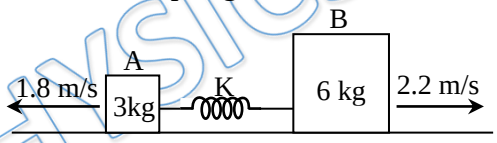
(a) y = - 5 cm (b) y = + 20 cm (c) y = + 5 cm (d) y = - 20 m

Q 6. In the arrangement shown in figure match the following:



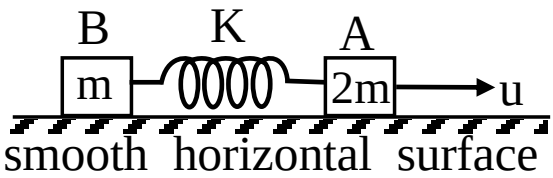

| Table-1 | | Table-2 | |
|---|---|---|---|
| **(A)** | Velocity of centre of mass | **(P)** | 2 SI unit |
| **(B)** | Velocity of combined mass when compression in the spring Is maximum | **(Q)** | 1 SI unit |
| **(C)** | Maximum compression in the spring | **(R)** | 4 SI unit |
| **(D)** | Maximum potential energy stored In the spring | **(S)** | 0.5 SI unit |

Q 7. Two blocks A(3kg) and B(6kg) are connected by a spring of stiffness 512 N/m and placed on a smooth horizontal surface. Initially the spring has its equilibrium length. Velocities 1.8m/s and 2.2 m/s are imparted to A and B in opposite direction. The maximum extension in the spring will be –



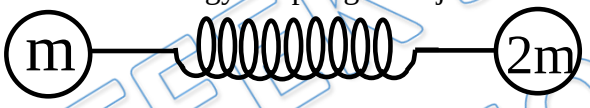

(a) 25 cm (b) 10 cm (c) 12 cm (d) 2.5 cm

Q 8. Two blocks A and B of mass m and 2m respectively are connected by a massless spring of spring constant K. This system lies over a smooth horizontal surface. At t = 0 the block A has velocity u towards right as shown while the speed of block B is zero, and the length of spring is equal to its natural length at that instant. In each situation of column-I, certain statements are given and corresponding results are given in column-II, Match the statements in column-I to the corresponding results in column-II :



| Column I | Column II |
|---|---|
| (A) The velocity of block A | (P) Can never be zero |
| (B) The velocity of block B | (Q) may be zero at certain instants of time |
| (C) The kinetic energy of system of two blocks | (R) is minimum at maximum compression of spring |
| (D) The potential energy of spring | (S) is maximum at maximum extension of spring |

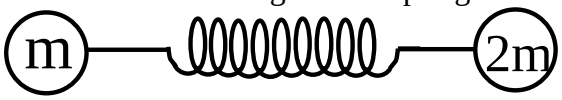
Q 9. Two masses m and 2m are attached to two ends of an ideal spring and the spring is in the compressed state. The energy of spring is 60 joule. If the spring is released, then-




(a) the energy of both bodies will be same
(b) energy of smaller body will be 10J
(c) energy of smaller body will be 20J
(d) energy of smaller body will be 40 J

Q 10. In last problem if initial compression was 12 cm, then maximum displacement of 2m is
(a) 4 cm (b) 8 cm
(c) 6 cm (d) 2 cm

Q 11. Two masses m and 2m are attached to two ends of an ideal spring of stiffness K and the spring is in its natural length. At t = 0, a constant force F starts acting on 2m in rightward direction. Maximum elongation in spring is

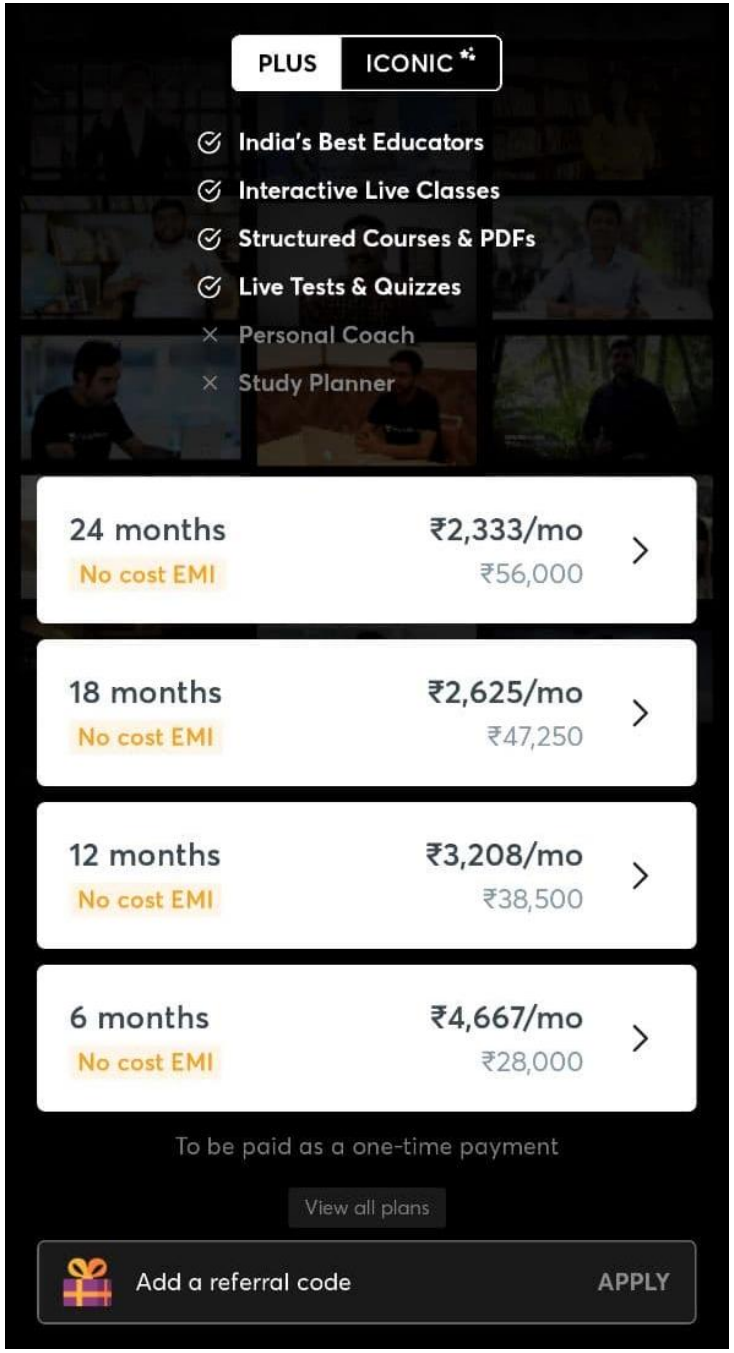



(a) 2F/K (b) F/K (c) F/2K (d) 2F/3K

Q 12. A gun of mass 2m when fitted (fixed) with ground fires bullet of mass m with velocity v. What will be velocity of same bullet if gun is free to move ?
(a) v (b) $\frac{v}{\sqrt{2}}$ (c) $v\sqrt{3/2}$ (d) $\frac{v}{\sqrt{3}}$

# Answer Key

| | | | | |
|---|---|---|---|---|
| **Q.1 a** | **Q.2 b** | **Q.3 a** | **Q.4 a** | **Q.5 a** |
| **Q.6** (A) Q, (b) Q, (C) Q, (D) p | **Q.7 a** | **Q.8** A → P ; B → Q ; C → P, R ; D → Q, S | **Q.9 d** | **Q.10 b** |
| **Q.11 d** | **Q.12 c** | | | |

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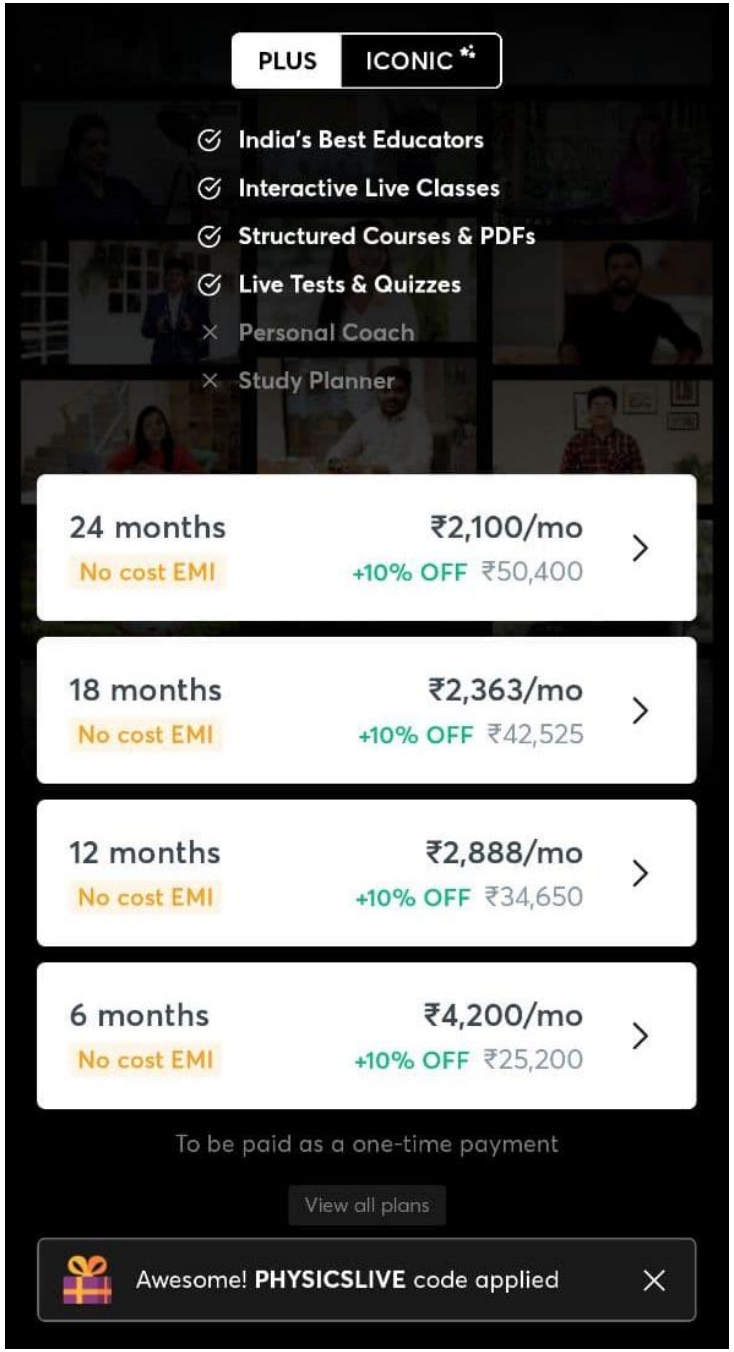
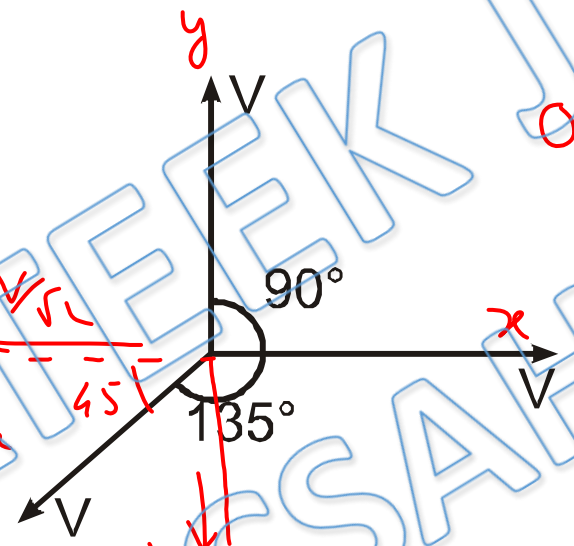


# Written Solution

## DPP- 7: Spring Blocks System , Explosion

## By Physicsaholics Team

Q.1) A particle of mass 4 m which is at rest explodes into four equal fragments. All 4 fragments scattered in the same horizontal plane. Three fragments are found to move with velocity V each as shown in the figure. The total energy released in the process of explosion is :




Energy produced = $K_f$

$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}mv_4^2$

$= \frac{3}{2}mv^2 + \frac{m}{2}(2+1-2\sqrt{2})v^2$

by COM →

$0 = mv\hat{i} + mv\hat{j} + m\left(-\frac{v}{\sqrt{2}}\hat{i} - \frac{v}{\sqrt{2}}\hat{j}\right) + m\vec{v_4}$

$\vec{v_4} = -v\left(1-\frac{1}{\sqrt{2}}\right)(\hat{i}+\hat{j})$

$v_4 = v\left(1-\frac{1}{\sqrt{2}}\right)\sqrt{2} = v(\sqrt{2}-1)$

(a) $mV^2(3-\sqrt{2})$ (b) $2mV^2$ (c) $mV^2\frac{(3-\sqrt{2})}{2}$ (d) $mV^2\frac{(1+\sqrt{2})}{2}$

$= \left(\frac{3}{2}mv^2 + \frac{3}{2}mv^2 - \sqrt{2}mv^2\right)$

$= mv^2(3-\sqrt{2})$

Q.2) A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 $ms^{-1}$. The kinetic energy of the other mass is :


$P = 18 \times 6$

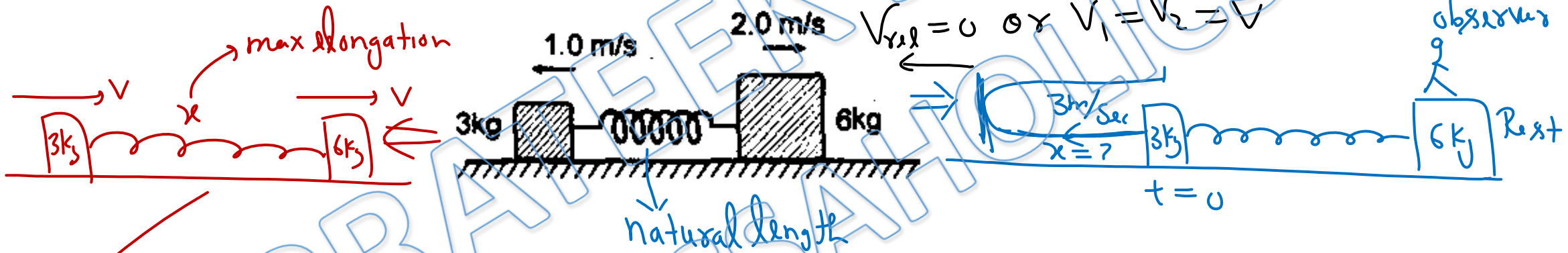
KE of 12 kg mass $= \frac{P^2}{2m} = \frac{18 \times 18 \times 6 \times 6}{2 \times 12} = 81 \times 6 = 486\ J.$

(a) 256 J (b) 486 J (c) 524 J (d) 324 J

Q.3) Two blocks of mass 3kg and 6 kg respectively are placed on a smooth horizontal surface. They are connected by a light spring of force constant k = 200 N/m. Initially the spring is unstretched. The indicated velocities are imparted to the blocks. The maximum extension of the spring will be:

$\mu = \frac{m_1 m_2}{m_1 + m_2} = \frac{3 \times 6}{3+6} = 2\,kg$

at max elongation $V_{rel} = 0$ or $V_1 = V_2 = V$




(a) 30 cm (b) 25 cm (c) 20 cm (d) 15 cm

by Conservation of momentum

$6 \times 2 - 3 \times 1 = 9V \Rightarrow V = 1\,m/sec.$

by Conservation of mechanical energy →

$\frac{1}{2} \times 6 \times 4 + \frac{1}{2} \times 3 \times 1^2 = \frac{1}{2} \times 9 \times 1^2 + \frac{1}{2} \times 200 x^2 \Rightarrow 100x^2 = 9$

$x = 3m$

by COME from CM frame →

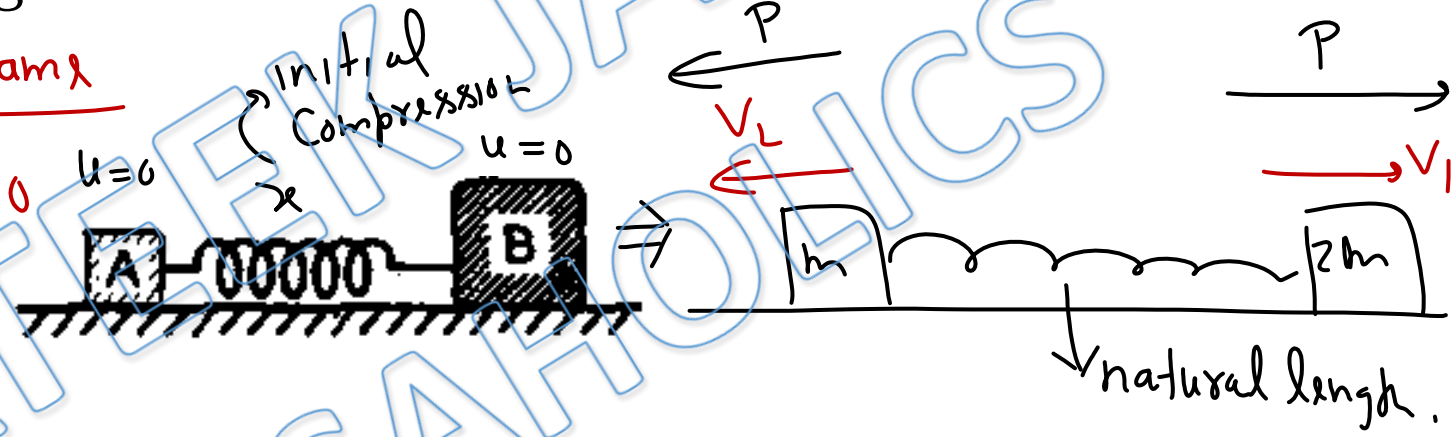
$\frac{1}{2} \times 2 \times 9 + 0 = 0 + \frac{1}{2} \times 100 x^2 \Rightarrow x = .3m$

Q.4) Two blocks A and B of mass m and 2m are connected by a massless spring of force constant k. They are placed on a smooth horizontal plane. Spring is stretched by an amount x and then released. The relative velocity of the blocks when the spring comes to its natural length is

by COME from CM frame

$0 + \frac{1}{2}kx^2 = \frac{1}{2}\left(\frac{m \times 2m}{3m}\right)v_{rel}^2 + 0$

$v_{rel} = x\sqrt{\frac{3k}{2m}}$




(a) $\left(\sqrt{\frac{3k}{2m}}\right)x$ (b) $\left(\sqrt{\frac{2k}{3m}}\right)x$ (c) $\sqrt{\frac{2kx}{m}}$ (d) $\sqrt{\frac{3kx}{2m}}$

OR

$\frac{1}{2}kx^2 = \frac{P^2}{2m} + \frac{P^2}{2\times 2m}$ --(1)

$P = ?$, $V_1 = ?$, $V_2 = ?$

$v_{rel} = V_1 + V_2$

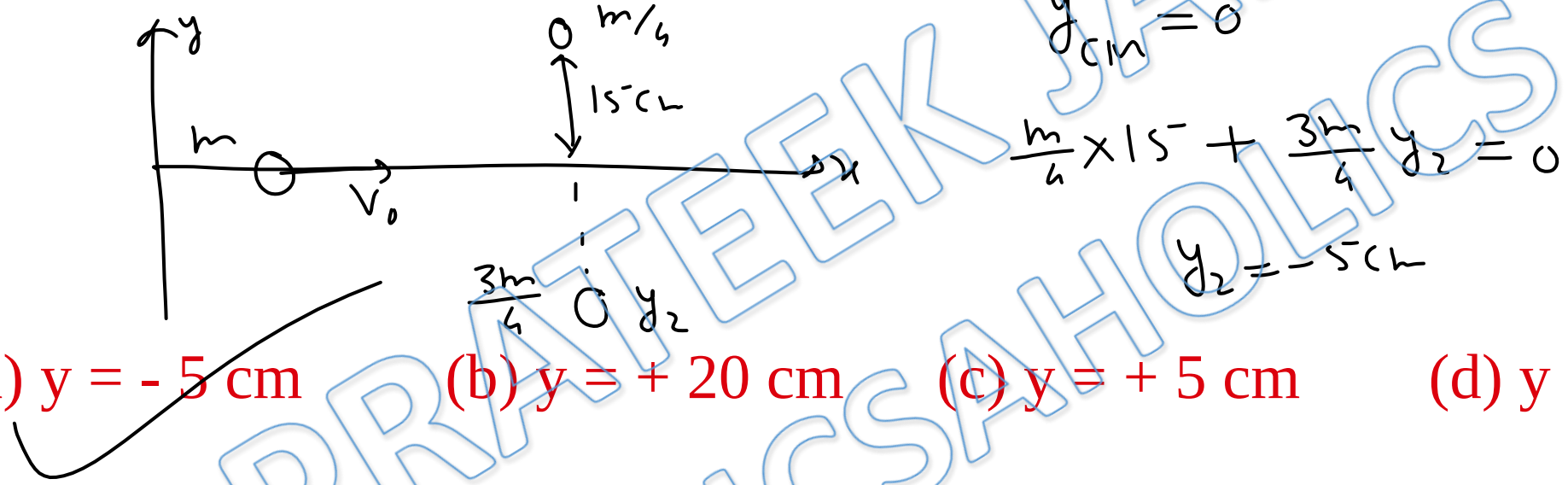
Alternate Method

$2mV_1 = mV_2$ --(I)

$\frac{1}{2}kx^2 = \frac{1}{2}\times 2mV_1^2 + \frac{1}{2}\times mV_2^2$ —(II)

$v_{rel} = V_1 + V_2$

Q.5) An isolated particle of mass m is moving in horizontal plane (x-y), along the x-axis, at a certain height above the ground. It suddenly explodes into two fragments of masses m/4 and 3m/4. An Instant later, the smaller fragment is at y = + 15 cm. The larger fragment at this instant is at :

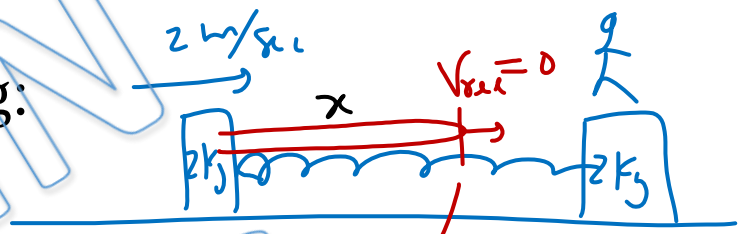



(a) y = - 5 cm (b) y = + 20 cm (c) y = + 5 cm (d) y = - 20 m

Q.6) In the arrangement shown in figure match the following:

$V_{CM} = \frac{2\times2}{4} = 1\ m/s$

at max Compression $V_1 = V_2 = V \Rightarrow 2\times2 = 4\times V \Rightarrow V = 1$




at max Compression

$\Rightarrow V_{rel} = 0$

$\Rightarrow V_1 = V_2 = V$

| Table-1 | | Table-2 |
|---|---|---|
| **(A)** Velocity of centre of mass | **(P)** | 2 SI unit |
| **(B)** Velocity of combined mass when compression in the spring Is maximum | **(Q)** | 1 SI unit |
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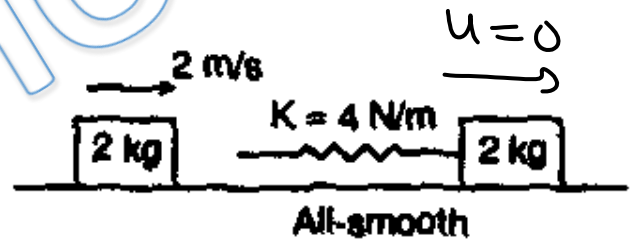
| **(D)** Maximum potential energy stored In the spring | **(S)** | 0.5 SI unit |




by COME →

$\frac{1}{2}\times2\times2^2 = \frac{1}{2}\times4\times1^2 + \frac{1}{2}\times4\times x^2$

$4 = 2 + 2x^2$

$x = 1\ m$

$PE_{max} = \frac{1}{2}\times4\times1^2 = 2$

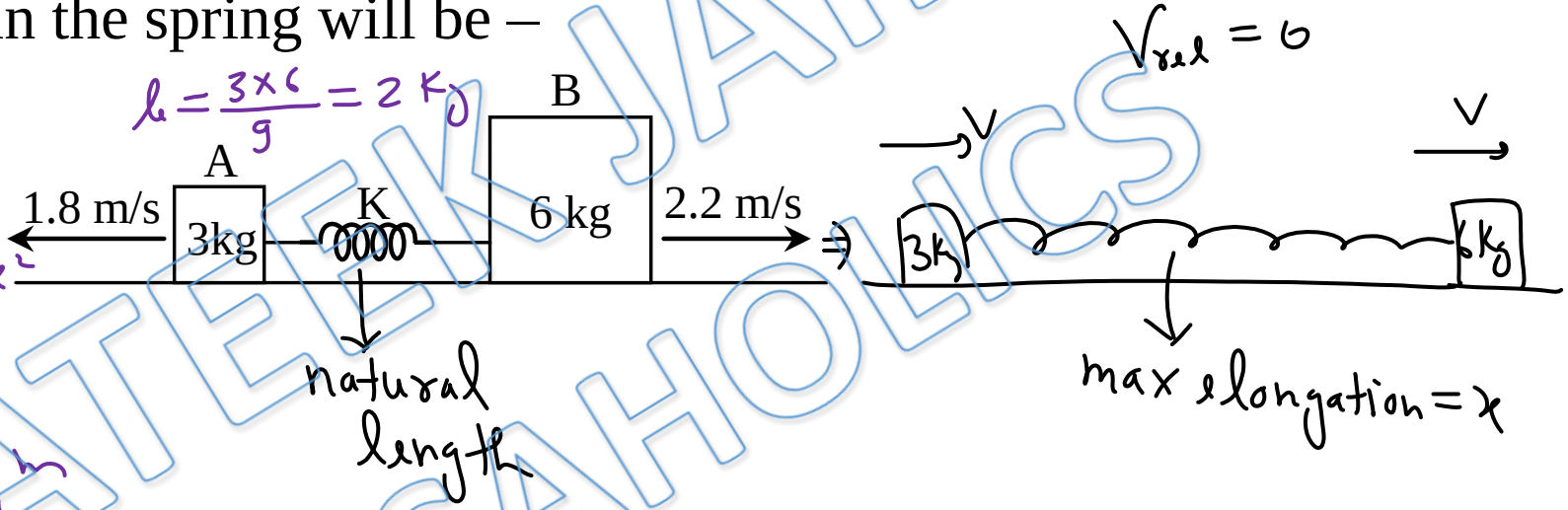
Q.7) Two blocks A(3kg) and B(6kg) are connected by a spring of stiffness 512 N/m and placed on a smooth horizontal surface. Initially the spring has its equilibrium length. Velocities 1.8m/s and 2.2 m/s are imparted to A and B in opposite direction. The maximum extension in the spring will be –

CM is inertial.

$\frac{1}{2}\times 2\times 4^2 = \frac{1}{2}\times 2\times 0^2 + \frac{1}{2}\times 512\times x^2$

$16 = 256\,x^2$

$x^2 = \frac{1}{16} \Rightarrow x = \frac{1}{4}\,m$




(a) 25 cm (b) 10 cm (c) 12 cm (d) 2.5 cm

Q.8) Two blocks A and B of mass m and 2m respectively are connected by a massless spring of spring constant K. This system lies over a smooth horizontal surface. At t = 0 the block A has velocity u towards right as shown while the speed of block B is zero, and the length of spring is equal to its natural length at that instant. In each situation of column-I, certain statements are given and corresponding results are given in column-II, Match the statements in column-I to the corresponding results in column-II :

$V_A$ is minimum or maximum $\Rightarrow a_A = 0 \Rightarrow$ spring is in natural length

$\Rightarrow V_B = \frac{2mu}{m} = 2u$

$\Rightarrow TME = \frac{1}{2}Kx^2 + \frac{1}{2}m(2u)^2$

$= \frac{1}{2}Kx^2 + 2mu^2$

$TME_1 = \frac{1}{2} \times 2mu^2 = mu^2$

| Column I | Column II |
|---|---|
| (A) The velocity of block A | (P) Can never be zero |
| (B) The velocity of block B | (Q) may be zero at certain instants of time |
| (C) The kinetic energy of system of two blocks | (R) is minimum at maximum compression of spring |
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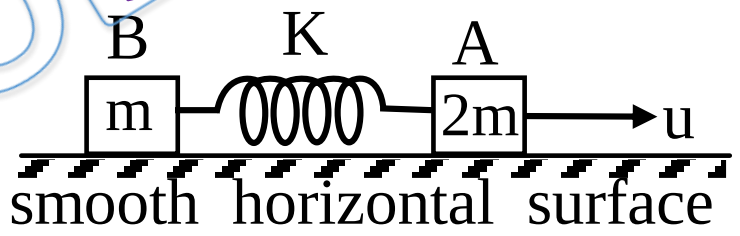
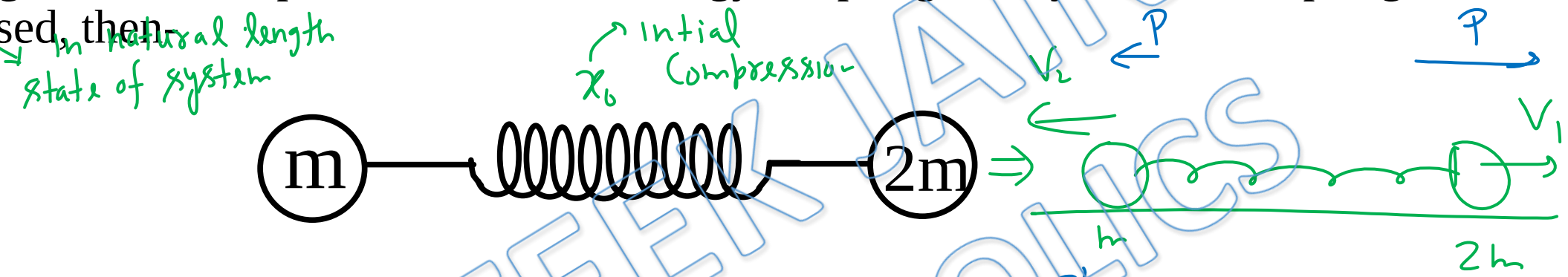



$u_B = 0$

Clearly not possible (against CME)

$\star$ $V_B = 0 \Rightarrow V_A = u$ & elongation $= 0$

Q.9) Two masses m and 2m are attached to two ends of an ideal spring and the spring is in the compressed state. The energy of spring is 60 joule. If the spring is released, then-




(a) the energy of both bodies will be same

(b) energy of smaller body will be 10J

(c) energy of smaller body will be 20J

(d) energy of smaller body will be 40 J

$K_1 = \frac{P^2}{2 \times 2m}$

$K_2 = \frac{P^2}{2m}$

$\frac{K_1}{K_2} = \frac{1}{2}$

$K_1 + K_2 = 60$

$K_1 = 20\ J.$

$K_2 = 40\ J$

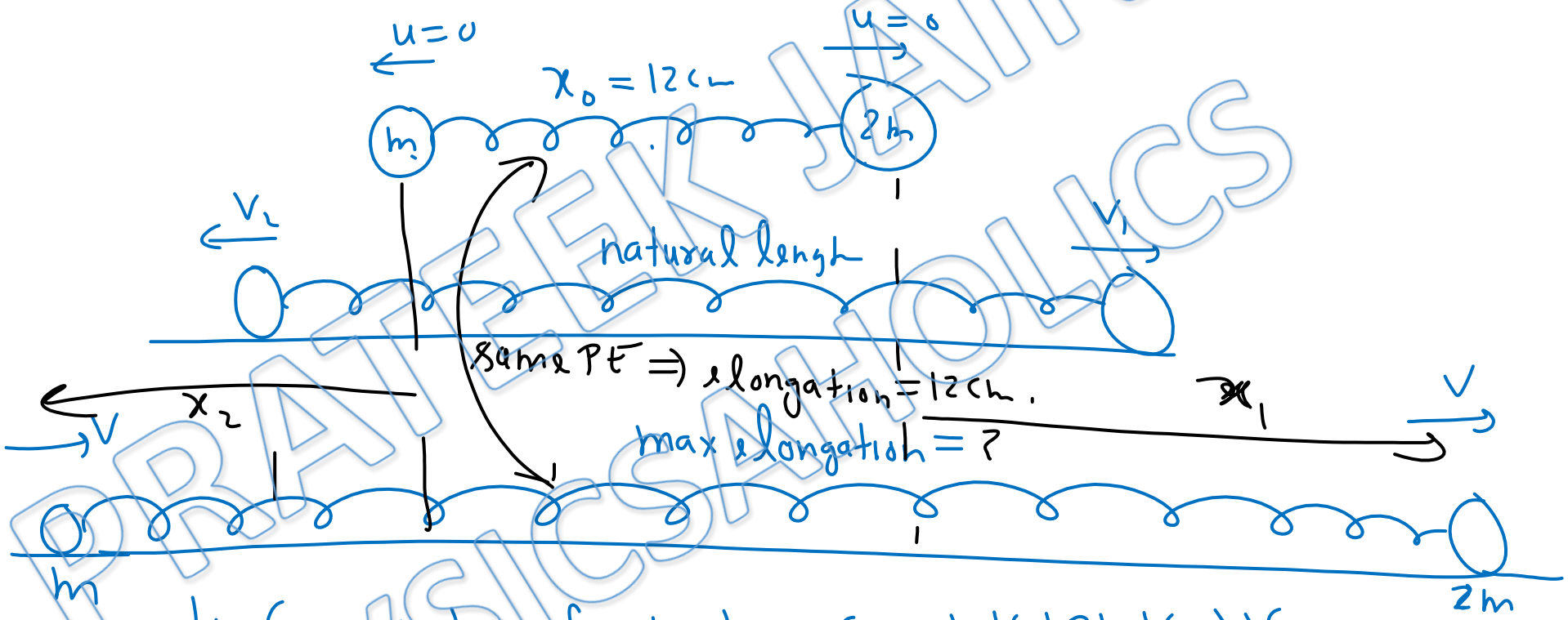
Q.10) In last problem if initial compression was 12 cm, then maximum displacement of 2m is

(a) 4 cm

(b) 8 cm

(c) 6 cm

(d) 2 cm



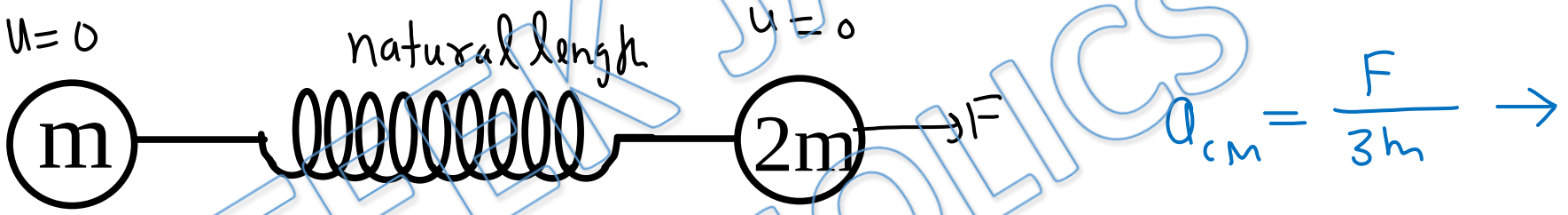

by Conservation of momentum $0 = mV + 2mV \Rightarrow V = 0$

$x_1 + x_2 = 24$ , Since CM is at rest $2m x_1 = m x_2$

$3x_1 = 24$

$x_1 = 8$ cm

Q.11) Two masses m and 2m are attached to two ends of an ideal spring of stiffness K and the spring is in its natural length. At t = 0 , a constant force F starts acting on 2m in rightward direction. Maximum elongation in spring is




$a_{CM} = \frac{F}{3m}$ →

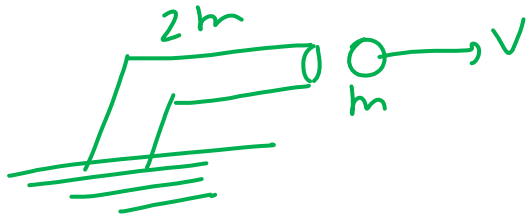
(a) 2F/K (b) F/K (c) F/2K (d) 2F/3K

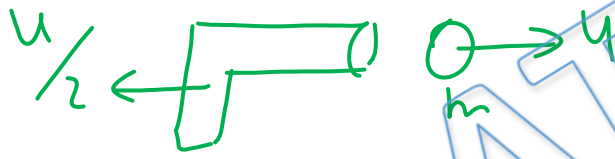

Using W-E theorem from CM →

$$\frac{F}{3}x_1 + \frac{F}{3}x_2 + \frac{1}{2}k\left[0^2 - (x_1+x_2)^2\right] = 0 - 0$$

$$\frac{F}{3}x - \frac{1}{2}kx^2 = 0 \Rightarrow x = 2F/3K$$

Q.12) A gun of mass 2m when fitted (fixed) with ground fires bullet of mass m with velocity v . What will be velocity of same bullet if gun is free to move ?




energy of explosion $= \frac{1}{2}mv^2$

energy of explosion $= \frac{1}{2}mu^2 + \frac{1}{2} \times 2m \frac{u^2}{4}$

$v\sqrt{2/3}$

(a) v (b) $\frac{v}{\sqrt{2}}$ (c) $v\sqrt{3/2}$ (d) $\frac{v}{\sqrt{3}}$

$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 + \frac{1}{2}\frac{mu^2}{2}$

$v^2 = \frac{3}{2}u^2$

$u = v\sqrt{\frac{2}{3}}$

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