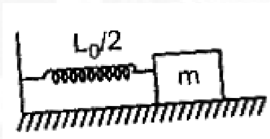
PART-I_PHYSICS Max Marks : 60

Section-1
(Only one Option correct Type)

This section contains 10 Multiple Choice questions. Each Question has Four choices (A), (B), (C) and (D). Out of Which **Only One is correct**

1. A block of mass m is pushed against a spring whose spring constant is k fixed at one end with a wall. The block can slide on a frictionless table as shown in figure. If the natural length of spring is L_0 and it is compressed to half its length when the block is released, find the velocity of the block, when the spring has natural length

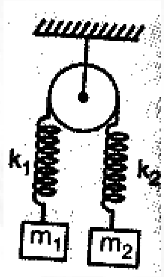


A) $\sqrt{\frac{m}{k_0}}.\frac{L_0}{2}$ B) $\sqrt{\frac{k_0}{m}}.\frac{L_0}{2}$ C) $\sqrt{\frac{k_0}{m}}.L_0$ D) $\sqrt{\frac{k_0 L_0}{m}}$

2. A particle of mass m is subjected to a force $\vec{F} = F_0\left[\cos(t)\hat{i} + \sin(t)\hat{i}\right]$. If initially (t = 0) the particle was at rest, the kinetic energy of the particle as a function of time is given by:

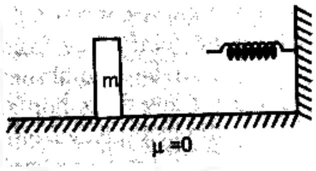
A) $\frac{F_0^2}{m}\left[1-\cos(2t)\right]$ B) $\frac{F_0^2}{m}\left[1-\cos t\right]$ C) $\frac{F_0^2}{m}\sin(t)$ D) $\frac{F_0^2}{m}t$

3. Two mass m_1 and m_2 joined by a mass less inextensible rope and two mass less springs of force constant k_1 and k_2 lie in a vertical plane. The pulley is smooth. When the system is released with the springs at their natural lengths, the maximum elongation of the spring (k_1) is:



A) $\frac{2m_1m_2g}{k_1(m_1+m_2)}$ B) $\frac{m_1m_2g}{k_1(m_1+m_2)}$ C) $\frac{4m_1m_2g}{k_1(m_1+m_2)}$ D) None of these

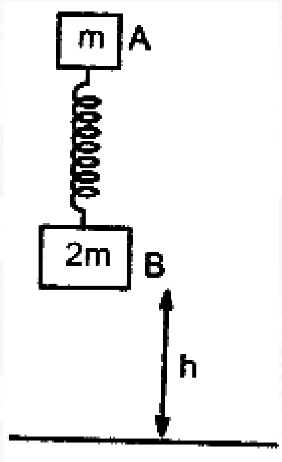
4. A block of mass m kg moving with kinetic energy 3 J on a smooth horizontal surface hits the free end of a spring, whose other end is attached to a rigid wall as shown in the figure. If restoring force applied by the spring is given by $F(x) = -2x - x^3\,(N)$



Then the maximum compression in the spring is approximately:

A) 2.20 m B) 1.51 m C) 1.41 m D) 1.67 m

5. From what minimum height h must the system be released when spring is unstretched so that after perfectly inelastic collision (e = 0) with ground, B may be lifted off the ground: (Spring constant = k)

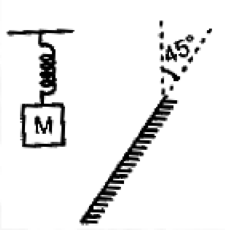


A) mg / (4k) B) 4mg/k C) mg/(2k) D) None of the above

6. Two particles move parallel to x-axis about the origin with same amplitude 'a' and frequency ω. At a certain instant they are found at a distance a/3 from the origin on opposite sides but their velocities are in the same direction. What is the phase diference between the two ?

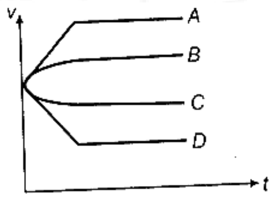
A) $\cos^{-1}\frac{7}{9}$ B) $\cos^{-1}\frac{5}{9}$ C) $\cos^{-1}\frac{4}{9}$ D) $\cos^{-1}\frac{1}{9}$

7. An insect of negligible mass is sitting on a block of mass M, tied with a spring of force constant k. The block performs simple harmonic motion with amplitude A infront of a plane mirror placed as shown in figure. The maximum speed of insect relative to its image will be:



A) $A\sqrt{\frac{k}{M}}$ B) $\frac{A}{\sqrt{2}}\sqrt{\frac{k}{M}}$ C) $A\sqrt{2}\sqrt{\frac{k}{M}}$ D) $A\sqrt{\frac{M}{k}}$

8. A solid sphere falls into a viscous liquid from a large height. Which of the graphs shown best represents the variation of velocity of sphere in liquid with time ?



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

9. A piston of 20 cm diameter and 20 cm long moves down in a cylinder of diameter 20.0628 cm. The oil filling the annular space has a viscosity of 10 Poise and the mass of the piston is 1 kg. Find the speed with which the piston slides down. (Given, g = 10 ms^{-2})

A) 15 cm^{-1} B) 2.5 cms^{-1} C) 2 cms^{-1} D) 3.5 cms^{-1}

10. A marble of mass x and diameter 2r is gently released in a tall cylinder containing honey. If the marble displaces mass $y(<x)$ of the liquid, then the terminal velocity is proportional to

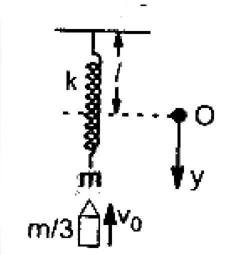
A) x + y B) x – y C) $\frac{x+y}{r}$ D) $\frac{x-y}{r}$

Section-2
(Paragraph Type)

This section contains 3 paragraphs each describing theory, experiment, data etc. Six questions relate to three paragraphs with two questions on each paragraph. Each question pertaining to a particular **paragraph** should have only one correct answer among the four choices A, B, C and D.

Paragraph for Questions 11 & 12:

A block of mass m is suspended from one end of a light spring as shown. The origin O is considered at distance equal to natural length of spring from ceiling and vertical downward direction as + ve y-axis. When the system is in equilibrium a bullet of mass m/3 moving in vertical upward direction with velocity v_0 strikes the block and embeds into it. As a result, the block (with bullet embedded into it) moves up and starts oscillating.



Based on above information, answer the following questions

11. The amplitude of oscillation would be:

A) $\sqrt{\left(\frac{4mg}{3k}\right)^2+\frac{mv_0^2}{12k}}$ B) $\sqrt{\frac{mv_0^2}{12k}+\left(\frac{mg}{3k}\right)^2}$

C) $\sqrt{\frac{mv_0^2}{6k}+\left(\frac{mg}{k}\right)^2}$ D) $\sqrt{\frac{mv_0^2}{6k}+\left(\frac{4mg}{3k}\right)^2}$

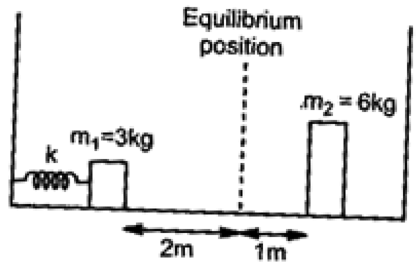
12. The time taken by block-bullet system to move from $y=\frac{mg}{k}$ (initial equilibrium position) to y =0 (natural length of spring). Is: [A represents the amplitude of motion]

A) $\sqrt{\frac{4m}{3k}}\left[\cos^{-1}\left(\frac{mg}{3kA}\right)-\cos^{-1}\left(\frac{4mg}{3kA}\right)\right]$ B) $\sqrt{\frac{3k}{4m}}\left[\cos^{-1}\left(\frac{mg}{3kA}\right)-\cos^{-1}\left(\frac{4mg}{3kA}\right)\right]$

C) $\sqrt{\frac{4m}{6k}}\left[\sin^{-1}\left(\frac{4mg}{3kA}\right)-\sin^{-1}\left(\frac{mg}{3kA}\right)\right]$ D) None of these

Paragraph for Questions 13 & 14:

Two blocks of masses 3 kg and 6 kg rest on a horizontal frictionless surface. The 3 kg block is attached to a spring with a force constant k = 900 N/m which is compressed 2 m initially from its equilibrium position. When 3 kg mass is released, it strikes the 6 kg mass and the two stick together in an inelastic collision.



13. The amplitude of resulting oscillation after the collision is:

A) $\frac{1}{\sqrt{2}}m$ B) $\frac{1}{\sqrt{3}}m$ C) $\sqrt{2}m$ D) $\sqrt{3}m$

14. The velocities of a particle executing S.H.M are 30 cm/s and 16 cm/s when its displacements are 8 cm and 15 cm from the equilibrium position. Then its amplitude of oscillation in cm is:

A) 25 B) 21 C) 17 D) 13

Paragraph for Questions 15 & 16:

An oil drop falls through air with a terminal velocity of $5\times10^{-4} m/s$. Viscosity of air $=1.8\times10^{-5} N-s/m^2$, density of oil = 900 kg/m^3. Neglect density of air as compared to that of oil.

15. The radius of the drop is

A) $2.14\times10^{-6} m$ B) $1.07\times10^{-6} m$ C) $4.28\times10^{-6} m$ D) $2.88\times10^{-6} m$

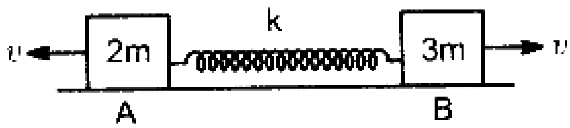
16. The terminal velocity of a drop of half of the radius in the above question

A) $2.5\times10^{-4} m/s$ B) $1.25\times10^{-4} m/s$ C) $5.15\times10^{-4} m/s$ D) $7.25\times10^{-4} m/s$

Section-3
(Matching List Type)

This section contains four questions, each having two matching lists (List-1 & List-II). The options for the **correct match** are provided as (A), (B),(C) and (D) out of which **ONLY ONE** is correct.

17. Two blocks A and B of masses 2m and 3m placed on smooth horizontal surface are connected with a light spring. The two blocks are given velocities as shown when spring is at natural length.

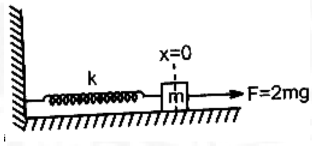


	Column I		Column II
i)	minimum magnitude of velocity of A $\left(v_{A_{\min}}\right)$ during motion	p)	v
ii)	maximum magnitude of velocity of A $\left(v_{A_{\max}}\right)$ during motion	q)	$\frac{v}{5}$
iii)	maximum magnitude of velocity of B $\left(v_{B_{\max}}\right)$ during motion	r)	0
iv)	velocity of centre of mass (v_{CM}) of the system comprised of blocks A, B and spring	s)	$\frac{7v}{5}$

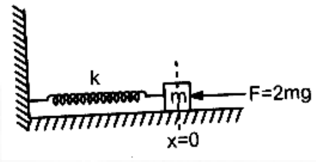
A)i-r; ii-s; iii-p; iv-q B)i-r; ii-p; iii-r; iv-s

C)i-s; ii-r; iii-q; iv-q D)i-p; ii-q; iii-p; iv-s

18. Columns I shows spring block system with a constant force permanently acting on block match entires of column I with column II.

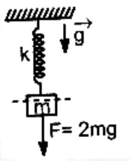
	Column I spring is initially relaxed when force is applied		Column II
i)		p)	Time period of oscillation $T = 2\pi\sqrt{\frac{m}{k}}$

spring is initially relaxed when force is applied

ii) 

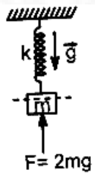
q) Amplitude of oscillation is $A = \frac{2mg}{k}$

Before force is applied block is in equilibrium position

iii) 

r) Maximum velocity attained by block is $2g\left[\sqrt{\frac{m}{k}}\right]$

When force is applied block is in equilibrium position

iv) 

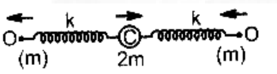
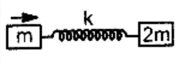
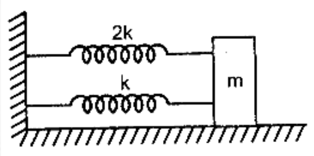
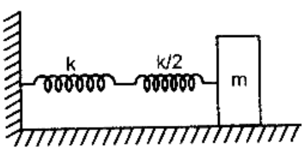
s) Maximum magnitude of acceleration of block is 2g

t) Velocity of block when spring is in anatural length is zero. If block acquire natural length

A)i-pqrst; ii-pqrst; iii-pqrs; iv-pqrs B)i-pq;ii-rs;iii-pqrs; iv-t

C)i-rs; ii-pq; iii-pqt; iv-pt D)i-pqst; ii-pqrst; iii-pqr; iv-qt

19. Column-I lists the various modes of oscillations of masses connected to springs. Column ii lists the corresponding frequencies of oscillations when executing S.H.M Match them properly

Column-I	**Column-II**
i) 	p) $\frac{1}{2\pi}\sqrt{\frac{3k}{2m}}$
ii) 	q) $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$
iii) 	r) $\frac{1}{2\pi}\sqrt{\frac{k}{3m}}$
iv) 	s) $\frac{1}{2\pi}\sqrt{\frac{3k}{m}}$

A)i-q; ii-r; iii-s; iv-p B)i-p; ii-r; iii-s; iv-q

C)i-q; ii-p; iii-s; iv-r D)i-r; ii-s; iii-p; iv-q

20. Column II depends on physical quantity/physical law given in column I. Match the following columns and select the correct option from the codes given below:

Column I		**Column II**	
i)	Stoke'l law	p)	Radius
ii)	Terminal velocity	q)	Density of material of the body
iii)	Excess pressure inside mercury drop	r)	Coefficient of viscosity
iv)	Viscous force on a plate moving horizontally on a liquid surface	s)	Surface tension
		t)	Velocity gradient

	i	**ii**	**iii**	**iv**
A)	pr	pqr	ps	rt
B)	ps	qr	st	pt
C)	p	qs	t	pqr
D)	q	s	pr	qs