| No. of Questions | Question Type | Marking Scheme | Maximum marks |
|---|---|---|---|
| 8 | Single Answer Type | 3 marks for correct answer; –1 for wrong | 24 |
| 4 | Multiple Answer Type | 4 marks for correct answer; –1 for wrong | 16 |
| 6 | Comprehension Type | 4 marks for correct answer; –1 for wrong | 24 |
| 2 | Matrix-Matches | 2 marks for each correct answer; No negative marking | 16 |
| **Total = 20** | | | **Total = 80** |

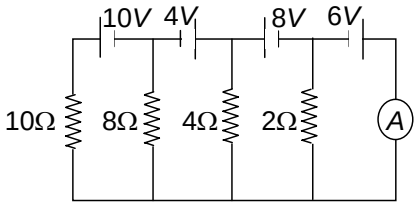
## SECTION – I

*This section contains 8 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which **ONLY ONE** is correct.*

**1.** A charge $q$ is placed at some distance along the axis of a uniformly charged disc of surface charge density $\sigma$. The flux due to the charge $q$ through the disc is $\phi$. The electric force on charge $q$ exerted by the disc is

(a) $\sigma\phi$ (b) $\frac{\sigma\phi}{4\pi}$ (c) $\frac{\sigma\phi}{2\pi}$ (d) $\frac{\sigma\phi}{3\pi}$

**2.** Find the reading of the ideal ammeter connected in the given circuit. Assume that the cells have negligible internal resistance.




(a) 0.8 A
(b) 0.25 A
(c) 1.95 A
(d) 1.0 A

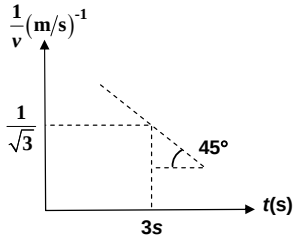
**3.** A ray of light strikes a horizontal plane mirror at an angle of 45°. A second plane mirror in attached at an angle $\theta$ with it. If ray after reflection from second mirror runs parallel to the first mirror, then $\theta$ is

(a) 45° (b) 60° (c) 67.5° (d) 135°

**4.** The moment of inertia of a cube of mass m and side 'a' about one of its edges is equal to

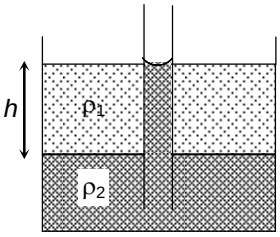
(a) $\frac{2}{3}ma^2$ (b) $\frac{4}{3}ma^2$ (c) $3ma^2$ (d) $\frac{8}{3}ma^2$

**5.** The diagram shows the variation of $\frac{1}{v}$ (where $v$ is velocity of the particle) with respect to time. At time $t = 3\,s$ using the details given in the graph, the instantaneous acceleration will be equal to




(a) $-2\,m/s^2$ (b) $+3\,m/s^2$
(c) $+5\,m/s^2$ (d) $-6\,m/s^2$

**6.** A container has two immiscible liquids of densities $\rho_1$ and $\rho_2\,(>\rho_1)$. A capillary tube of radius $r$ is inserted in the liquid so that its bottom reaches upto the denser liquid. The denser liquid rises in the capillary and attains a height $h$ from the interface of the liquids, which is equal to the column length of the lighter liquid. Assuming angle of contact to be zero, the surface tension of heavier liquid is :

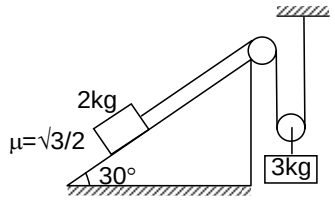



(a) $2\pi r\rho_2 gh$ (b) $\frac{\rho_2 rgh}{2}$ (c) $\frac{r}{2}(\rho_2-\rho_1)gh$ (d) $2\pi r(\rho_2-\rho_1)gh$

**7.** If the system is released from rest, then match the column:

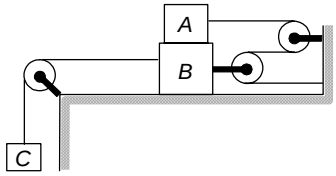
(i) acceleration of 2 kg mass
(ii) acceleration of 3 kg mass
(iii) tension in the string connecting 2 kg mass
(iv) frictional force on 2 kg mass

(a) 2 SI unit
(b) 5 SI unit
(c) zero
(d)none of these




(a) (i) c (ii) b (iii) d (iv) a
(b) (i) c (ii) a (iii) b (iv) d
(c) (i) c (ii) c (iii) d (iv) b
(d) (i) c (ii) c (iii) d (iv) d

**8.** What is the largest mass of C in kg that can be suspended without moving blocks A and B. The static coefficient of friction for all plane surface of contact is 0.3. Mass of block A is 50kg and block B is 70kg. Neglect friction in the pulleys:

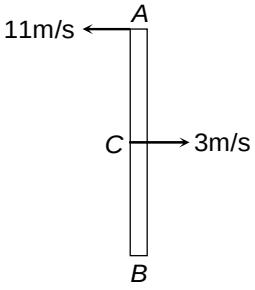



(a) 120 kg
(b) 92 kg
(c) 81 kg
(d) None of these

## SECTION – II

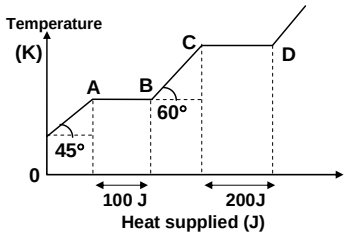
*This section contains 4 multiple type questions. Each Question has 4 choices (a), (b), (c) and (d), for its answer, out of which **ONE OR MORE** is/are correct.*

**9.** A uniform rod *AB* of length 7*m* is undergoing combined rotational and translational motion such that, at some instant of time, velocities of its end points *A* and centre *C* are both perpendicular to the rod and opposite in direction, having magnitudes 11 m/s and 3 m/s respectively as shown in the figure. Velocity of centre *C* and angular velocity of the rod remains constant.



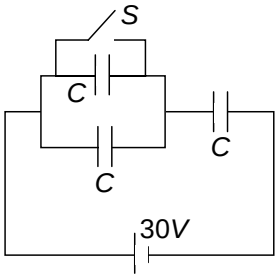

(a) acceleration of point *A* is 56 m/s$^2$
(b) acceleration of point *B* is 56 m/s$^2$
(c) at the instant shown in the figure acceleration of point *B* is more than that of point *A*.
(d) angular velocity of the rod is 4 rad/sec

**10.** The temperature change versus heat supplied curve is given for 1 kg of a solid block. Then, which of the following statements is/are correct?




(a) Specific heat capacity of the solid is 1 J/kg K.
(b) Specific heat capacity of liquid phase is $\sqrt{3}$ J/kg K.
(c) Latent heat of vaporization is 100 J/kg
(d) Latent heat of vaporization is 200 J/kg.

**11.** Three capacitors each having capacitance $C$ = 2μF are connected with a battery of emf 30 V as shown in the figure. When the switch *S* is closed, then




(a) the amount of charge flown through the battery is 20 μC
(b) the heat generated in the circuit is 0.6 mJ
(c) the energy supplied by the battery is 0.6 mJ
(d) the amount of charge flown through the switch *S* is 60 μC

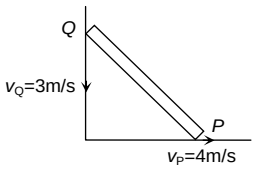
**12.** A uniform rod of mass $m$ = 2 kg and length $\ell$ = 0.5 m is sliding along two mutually perpendicular smooth walls with the two ends *P* and *Q* having velocities $v_P$ = 4m/s and $v_Q$ =3m/s as shown. Then:

(a) The angular velocity of rod, $\omega$ =10 rad/s, counter clokwise .

(b) The angular velocity of rod $\omega = 5.0$ rad/s. counter clockwise

(c) The velocity of center of mass of rod, $v_{cm} = 2.5\,m/s$ .

(d) The total kinetic energy of rod, $K = \frac{25}{3}$ joule.

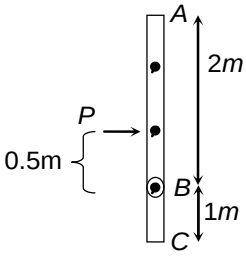



## SECTION – III

*This section contains 3 groups of questions. Each group has 2 multiple choice questions based on a paragraph. Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which* ***ONLY ONE*** *is correct*

**PASSAGE I : Q13 to Q14**

*Two uniform rods* AB *and* BC *of masses* 1kg *and* 2kg *having lengths* 2m *and* 1m *respectively are joined to each other at* B. *The assembly is kept on a smooth horizontal surface as shown in figure. A horizontal impulse* P = 10 N-s *is applied on the rod* AB *at a distance* 0.5 m *from point* B *perpendicular to the rod.*




**13.** Velocity of centre of rod *AB* just after the application of impulse is

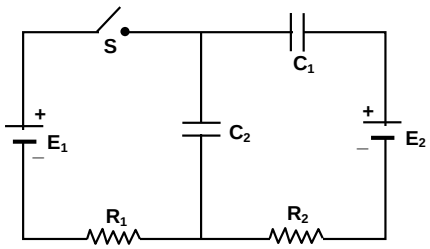
(a) $\frac{25}{12}$ m/s (b) $\frac{35}{6}$ m/s (c) $\frac{25}{2}$ m/s (d) 6 m/s

**14.** Impulse applied by the rod *BC* on the rod *AB* during application of impulse *P* is

(a) 25 N-s (b) 10 N-s (c) $\frac{25}{6}$ N-s (d) 12.5 N-s

**PASSAGE II : Q15 to Q16 :**

*In the circuit shown in figure,* $E_1 = E_2 = 100$ *volt,* $R_1 = R_2 = 4\Omega$, $C_1 = 6\mu F$ *and* $C_2 = 3\mu F$. *When switch S is closed and electrical equilibrium is attained.*




**15.** Energy drawn from battery $E_1$ after closing the switch is :

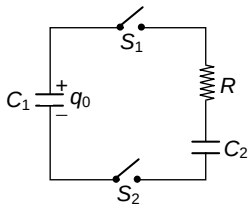
(a) 0.03 J (b) 0.02 J (c) –0.03J (d) –0.02 J

**16.** Heat generated in the circuit is :

(a) 0.003 J (b) 0.002 J (c) 0.005J (d) 0.006 J

**PASSAGE III : Q17 to Q18 :**

*The capacitor* $C_1$ *in the figure shown initially carries a charge* $q_0$. *When the switches* $S_1$ and $S_2$ *are closed, capacitor* $C_1$ *is connected in series to a resistor R and a second capacitor* $C_2$, *which is initially uncharged.*




**17.** Find the charge flown through wires as a function of time.

(a) $q_o e^{-t/RC} + \frac{C}{C_2} q_o$ (b) $\frac{q_o C}{C_1} \times \left[1 - e^{-t/RC}\right]$ (c) $q_o \frac{C}{C_1} e^{-t/CR}$ (d) $q_o e^{-t/RC}$

where C = $\frac{C_1 C_2}{C_1 + C_2}$

**18.** Find the total heat dissipated in the circuit during the discharging process of $C_1$.

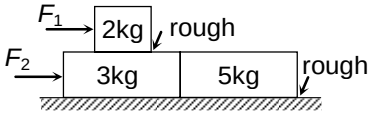
(a) $\frac{q_0^{\,2}}{2C_1^{\,2}} \times C$ (b) $\frac{q_o^{\,2}}{2C}$ (c) $\frac{q^2{}_o C_2}{2C_1^{\,2}}$ (d) $\frac{q_o^{\,2}}{2C_1 C_2}$

## SECTION – IV

*This section contains 2 questions. Each question contains statements given in two columns which have to be matched. The statements in column – I are labeled (A), (B), (C) and (D), while the statements in Column-II are labeled p, q, r, and s. Any given statement in column – I can have correct matching with **ONE OR MORE** statement(s) in Column – II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example.*
*If the correct matches are A-p, s; B-q and r; C-p and q; and D-s; then the correct darkening of bubbles will look like the following*

| | p | q | r | s |
|---|---|---|---|---|
| **A** | ● | ○ | ○ | ● |
| **B** | ○ | ● | ● | ○ |
| **C** | ● | ● | ○ | ○ |
| **D** | ○ | ○ | ○ | ● |

**19.** In the given figure, coefficient of friction between the 2kg and 3kg blocks are $\mu_S = 0.3$ and $\mu_K = 0.2$, between the 5kg and ground are $\mu_S = \mu_K = 0.1$ and between 3kg and ground are $\mu_S = \mu_K = 0$, ($g$ = 10 m/s$^2$).




| COLUMN – I | | COLUMN – II | |
|---|---|---|---|
| (A) | For $F_1 = 0,\ F_2 = 15\,N$ | (p) | Acceleration of all blocks will be same |
| (B) | For $F_1 = 6.25N,\ F_2 = 0$ | (q) | Acceleration of 2kg and 3kg blocks will be different |
| (C) | For $F_1 = 8N,\ F_2 = 10\,N$ | (r) | Frictional force between 2kg and 3kg block is less than maximum static friction |
| (D) | For $F_1 = 16\,N,\ F_2 = 9\,N$ | (s) | Contact force between 3kg and 5kg block is less than 10 N. |

**20.** In circular motion suppose $\vec{a}$ is the acceleration of particle, $\vec{v}$ its linear velocity and $\vec{w}$ its angular velocity. Then match the following column :

| Column – I | | Column – II | |
|---|---|---|---|
| (A) | $\lvert\vec{a}\times\vec{v}\rvert$ | (p) | positive |
| (B) | $\vec{a}\cdot\vec{v}$ | (q) | negative |
| (C) | $\vec{w}\cdot\vec{v}$ | (r) | Zero |
| (D) | $\lvert\vec{w}\times\vec{a}\rvert$ | (s) | undefined |

| No. of Questions | Question Type | Marking Scheme | Maximum Marks |
|---|---|---|---|
| 4 | Single Answer Type | 3 marks for correct answer; –1 for wrong | 12 |
| 5 | Multiple Answer Type | 4 marks for correct answer; –1 for wrong | 20 |
| 2 | Matrix-Matches | 2 marks for each correct answer; No negative marking | 16 |
| 8 | Single Digit Integer Answer Type | 4 marks for correct answer; –1 for wrong | 32 |
| **Total = 19** | | | **Total = 80** |

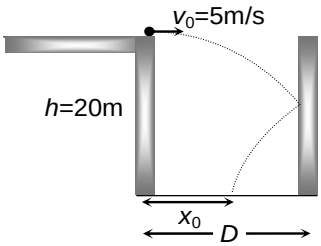
## SECTION – I

*This section contains 4 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which **ONLY ONE** is correct.*

**1.** A ball is thrown from the ground to clear a wall 3 m high at a distance of 6 m and falls 18 m away from the wall, the angle of projection of ball is :

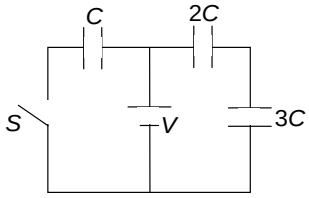
(a) $\tan^{-1}\left(\frac{3}{2}\right)$ (b) $\tan^{-1}\left(\frac{2}{3}\right)$ (c) $\tan^{-1}\left(\frac{1}{2}\right)$ (d) $\tan^{-1}\left(\frac{3}{4}\right)$

**2.** A ball leaves a horizontal table with velocity $v_0 = 5$ m/s . The ball bounces elastically from a vertical wall at a horizontal distance $D$ (= 8m) from the table, as shown in figure. The ball then strikes the floor a distance $x_0$ from the table ($g$ = 10 m/s$^2$). The value of $x_0$ is



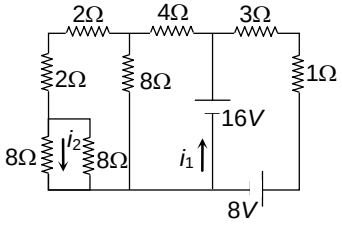

(a) 6 m (b) 4 m
(c) 5 m (d) 7 m

**3.** In the given circuit diagram, find the heat generated on closing the switch $S$. (initially the capacitor of capacitance $C$ is uncharged)




(a) $\frac{3}{2}CV^2$ (b) $CV^2$
(c) $\frac{1}{2}CV^2$ (d) none of these

**4.** In the circuit shown in figure the ratio of currents $i_1/i_2$ is

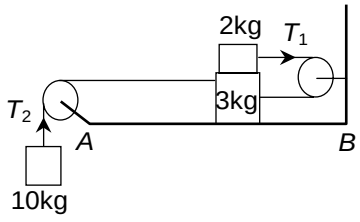



(a) 2
(b) 8
(c) 0.5
(d) 4

## SECTION – II

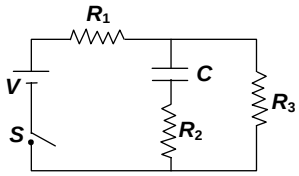
*This section contains 5 multiple type questions. Each Question has 4 choices (a), (b), (c) and (d), for its answer, out of which **ONE OR MORE** is/are correct.*

**5.** Coefficient of friction between the two blocks is 0.3 whereas the surface $AB$ is smooth. ($g$ = 10 m/s$^2$)




(a) Acceleration of the system of masses is 5.86 ms$^{-2}$
(b) Tension $T_1$ in the string is 17.7 N
(c) Tension $T_2$ in the string is about 41.4 N
(d) Acceleration of 10 kg mass is 7.55 ms$^{-2}$

**6.** In the circuit shown in figure, $R_1 = R_2 = R_3 = R$. Switch is closed at time $t = 0$. Then,



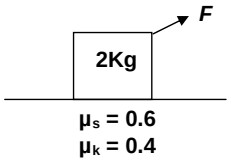

(a) potential difference across $R_2$ is equal to potential difference across $R_3$ at $t = \left(\frac{CR}{2}\right)\ln(2)$

(b) maximum current through $R_3$ is $\frac{V}{2R}$

(c) minimum current through $R_3$ is $\frac{V}{2R}$

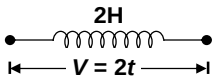
(d) maximum charge stored in the capacitor is $\frac{V}{2}C$

**7.** A force $F$ is applied on a block of mass 2 kg as shown in figure. $\left(g = 10 m/s^2\right)$.



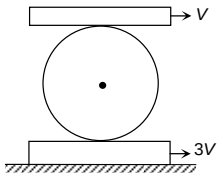

(a) The force of friction when the block is moving is 8N.
(b) The force of friction when the block is stationary is less than 12 N.
(c) Block will not leave contact with ground for any value of $F$.
(d) The force of friction when the block is moving is less than 8 N.

**8.** A variable voltage $V = 2t$ is applied across an inductor of inductance $L = 2H$ as shown in figure. Then




(a) current versus time graph is a parabola
(b) energy stored in magnetic field at $t = 2$ sec is 4 $J$
(c) potential energy at time $t$ = 1 sec in magnetic field is increasing at a rate of 1 $J$/s
(d) energy stored in magnetic field is zero all the time.

**9.** A cylinder of radius $R$ is to roll without slipping between two planks as shown in the figure. Then:




(a) angular velocity of the cylinder is $\frac{v}{R}$ counter clockwise

(b) angular velocity of the cylinder is $\frac{2v}{R}$ clockwise

(c) velocity of centre of mass of the cylinder is $v$ towards left

(d) velocity of centre of mass of the cylinder is $2v$ towards right

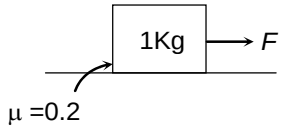
## SECTION – III

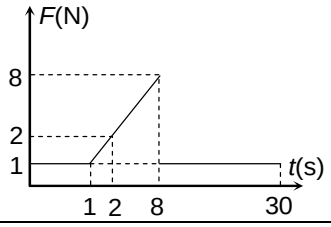
*This section contains 2 questions. Each question contains statements given in two columns which have to be matched. The statements in column – I are labeled (A), (B), (C) and (D), while the statements in Column-II are labeled p, q, r, and s. Any given statement in column – I can have correct matching with **ONE OR MORE** statement(s) in Column – II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example.*

*If the correct matches are A-p, s; B-q and r; C-p and q; and D-s; then the correct darkening of bubbles will look like the following*

| | P | q | r | s |
|---|---|---|---|---|
| A | ● p | ○ | ○ | ● s |
| B | ○ | ● q | ● r | ○ |
| C | ● p | ● q | ○ | ○ |
| D | ○ | ○ | ○ | ● s |

**10.** A block of mass 1 kg is placed on a rough horizontal surface of coefficient of friction $\mu = 0.2$. A force is applied on the block horizontally whose variation with time is shown in the figure.



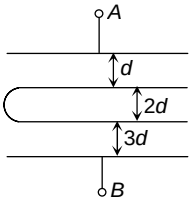




| COLUMN – I | | COLUMN – II | |
|---|---|---|---|
| (A) | Velocity of particle is zero at | (p) | $t = 1$ s |
| (B) | Acceleration of particle is non-zero at | (q) | $t = 4$ s |
| (C) | Friction force = 1 N | (r) | $t = 20$ s |
| (D) | Friction force $\geq F$ | (s) | $t = 30$ s |

**11.** The equivalent capacitance across *AB* for the plates connected as shown in column I, are given in column II. Match the items in column II with the items in column I. Area of each plate is A unless mentioned.

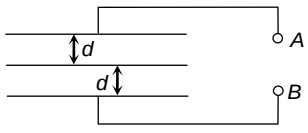
**Column –I** **Column II**

(A)



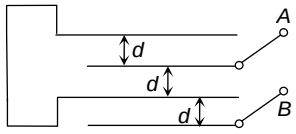

(p) $\frac{3\varepsilon_0 A}{4d}$

(B)



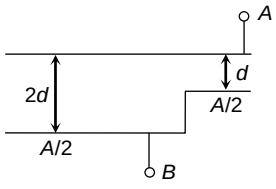

(q) $\frac{2\varepsilon_0 A}{3d}$

(C)




(r) $\frac{\varepsilon_0 A}{4d}$

(D)




(s) $\frac{\varepsilon_0 A}{2d}$

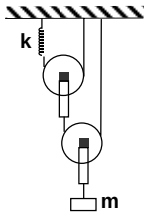
## SECTION – IV

*This section contains 8 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened. For example, if the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2, respectively, then the correct darkening of bubbles will look like the following*

| *X* | *Y* | *Z* | *W* |
|---|---|---|---|
| 0 | **0** | 0 | 0 |
| 1 | 1 | 1 | 1 |
| 2 | 2 | 2 | **2** |

| | | | |
|---|---|---|---|
| 3 | 3 | 3 | 3 |
| 4 | 4 | 4 | 4 |
| 5 | 5 | 5 | 5 |
| **6** | 6 | 6 | 6 |
| 7 | 7 | 7 | 7 |
| 8 | 8 | 8 | 8 |
| 9 | 9 | **9** | 9 |

**12.** Find the natural frequency (in Hz) of the system as shown in the figure. The pulleys are massless and frictionless.

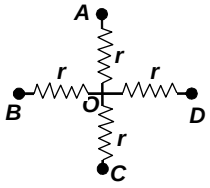



☞ **Take :** $k = \left(\pi^2\right)\frac{N}{m}$ and $m = 1$ kg

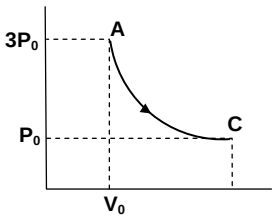
**13.** A ring rolls on a horizontal surface without sliding. The velocity of the centre is *v*. It encounters a step of height 0.3 R where R is the radius of the ring. Calculate the angular velocity (in radian/second) of the ring just after the impact. Assume that the ring does not return back. (and there is sufficient friction to avoid slipping).

☞ **Take :** $V = 6\frac{m}{s}$ and $R = 1.7\ m$

**14.** The four terminal network shown in the figure consists of four equal resistors and is a part of a larger circuit. The points *A*, *B* and *C* are at same potential. The potential difference between *A* and *D* is 4 volts. Find potential difference (in Volts) between *O* and *D*.

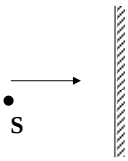



**15.** The pressure and volume of an ideal gas are related as $P \propto \frac{1}{V^2}$ for a process $A \to C$ as shown in the figure. The pressure and volume at *A* is $3P_0$ and $V_0$ respectively and the pressure at *C* is $P_0$. Find the work done (in J) in the process $A \to C$

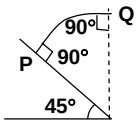



**Given that :** $P_0V_0 = \left(3+\sqrt{3}\right)J$

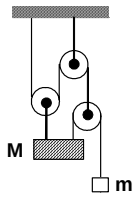
**16.** A source *S* having a detector *D* moving towards a wall with a certain velocity detects 9 beats per second. On doubling the velocity of the source, the detector *D* detects 20 beats per second. The original frequency of sound source is $\frac{205}{x}$. Find value of *x*. Take speed of sound as 330 m/s.



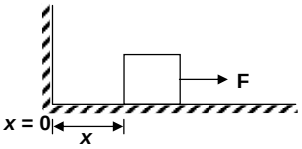

**17.** A ball is projected normally from point *P* (which is on an inclined plane) with speed *u*. It strikes the vertical wall normally. If all the collisions are perfectly elastic, then find the time period (in seconds) of periodic motion.




**Given :** $u = 10\sqrt{2}\frac{m}{s}$, $g = 10\frac{m}{s^2}$




**18.** The magnitude of acceleration of M is $\frac{g}{x}$. Find the value of $x$. Given that $\frac{M}{m} = 2.$




**19.** The block of mass '$m$' initially at $x = 0$ is acted upon by a horizontal force $F = a - bx$ as shown in the figure. The coefficient of friction between the surfaces of contact is μ. The net work done on the block is zero. The distance traveled by the block before stopping is $x$/5 m. Find value of $x$.

**Take :** $a$=1N,$b$=1N/m,μ = 0.3, $g = 10\frac{m}{s^2}$ and $m$ = 0.1 Kg