SAMPLE PAPER - 6

Class 11 - Physics

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

Section A

1. If the acceleration due to gravity is represented by unity in a system of units and one second be the unit of time, the unit of length is: **[1]**

a) 9.8 m
b) 98 m
c) 1 m
d) 0.98 m

2. An engineer claims to have made an engine delivering 10 kW power with fuel consumption of 1 g/s. The calorific value of the fuel is 2 kcal/g This claim is: **[1]**

i. valid
ii. invalid
iii. depends on engine design
iv. dependent on load

a) only ii
b) i and ii
c) iv and i
d) iii and iv

3. If there is change of angular momentum from j to 4 j in 4s, then the torque is **[1]**

a) $\frac{5}{4}j$
b) $\frac{4}{3}j$
c) 1 j
d) $\frac{3}{4}j$

4. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied? **[1]**

a) Length = 50 cm, diameter = 0.5 mm
b) Length = 200 cm, diameter = 2 mm

c) Length = 300 cm, diameter = 3 mm

d) Length = 100 cm, diameter = 1mm

5. A body is orbiting very close to the earth's surface with kinetic energy KE. The energy required to completely escape from it is: [1]

a) KE

b) $\frac{KE}{\sqrt{2}}$

c) None of these

d) $\sqrt{2}KE$

6. A polyatomic gas with n degrees of freedom has a mean kinetic energy per molecule given by: [1]

a) $\frac{nKT}{2N}$

b) $\frac{3KT}{2}$

c) $\frac{nKT}{N}$

d) $\frac{nKT}{2}$

7. During an adiabatic compression, 830 J of work is done on 2 moles of a diatomic ideal gas to reduce its volume by 50%. The change in its temperature is nearly: (R = 8.3 JK^{-1} mol^{-1}) [1]

a) 33K

b) 40K

c) 14K

d) 20K

8. A number of tuning forks are arranged in the order of increasing frequency and any two successive tuning forks produce 4 beats per second, when sounded together. If the last tuning fork has a frequency octave higher than that of the first tuning fork and the frequency of the first tuning fork is 256 Hz, then the number of tuning forks is: [1]

a) 66

b) 65

c) 63

d) 64

9. A liquid drop of radius R is broken up into N small droplets. The work done is proportional to(take $N^{\frac{1}{3}}$ >> 1). [1]

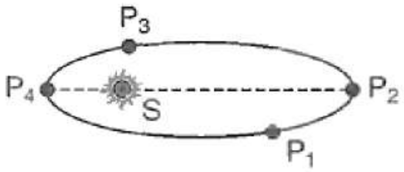
a) $N^{\frac{1}{3}}$

b) N

c) $N^{\frac{-2}{3}}$

d) $N^{-0.5}$

10. Figure shows a planet in an elliptical orbit around the sun S. Where is the kinetic energy of the planet maximum? [1]



a) P_3

b) P_1

c) P_2

d) P_4

11. The drive shaft of an automobile rotates at 3600 rpm and transmits 80 HP up from the engine to the rear wheels. The torque developed by the engine is: [1]

a) 0.022 Nm

b) 141.6 Nm

c) 16.58 Nm

d) 158.31 Nm

12. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K, the root mean square speed of gas molecules is v, then at 480 K it wilt be: [1]

a) $\frac{v}{2}$

b) 4v

c) 2v

d) $\frac{v}{4}$

13. A plane sound wave is travelling in a medium. With reference to a frame A, its equation is y = a cos (ωt - kx). With reference to a frame B, moving with a constant velocity v in the direction of propagation of the wave, equation of the wave will be: **[1]**

a) y = a cos [(ω + kv)t - kx]

b) y = a cos [(ω + kv)t - kx]

c) y = -a cos [(ω - kv)t - kx]

d) y = a cos [(ω - kv)t - kx_0]

14. A gas is compressed adiabatically till its temperature is doubled. The ratio of its final volume to initial volume will be: **[1]**

a) Less than 0.5

b) Between 1 and 2

c) More than 0.5

d) Equal to 0.5

15. The acceleration due to gravity at the poles and the equator is g_p and g_e respectively. If the earth is a sphere of radius R and rotating about its axis with angular speed co, then g_p - g_e is given by: **[1]**

a) $\omega^2 R^2$

b) $\frac{\omega^2}{R^2}$

c) $\frac{\omega^2}{R}$

d) $\omega^2 R$

16. **Assertion (A):** In uniform circular motion of a body, its linear speed remains constant. **[1]**
Reason (R): Total acceleration of the body has no radial component.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

17. **Assertion:** Bulk modulus of incompressible liquid is infinity. **[1]**
Reason: The volume of incompressible liquid does not change by applying force.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

18. **Assertion (A):** $\frac{L}{R}$ and CR both have same dimensions. **[1]**
Reason (R): $\frac{L}{R}$ and CR both have dimension of time.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

Section B

19. State the number of significant figures in the following : **[2]**

i. 0.2370 g cm^{-3}
ii. 6.320 J

20. Define impulse and impulse-momentum theorem. **[2]**

21. The gravitational force exerted by the sun on the moon is greater than (about twice as great as) the gravitational **[2]**

force exerted by the earth on the moon. Why then doesn't the moon escape from the earth (during a solar eclipse, for example)?

OR

Draw areal velocity versus time graph for mars.

22. A wire of length L, area of cross-section A and young's modulus Y is stretched by an amount x. What is the work done? **[2]**

23. What is meant free path of a gas molecule? On what factors does the mean free path depend? **[2]**

OR

Calculate the rms speed of a oxygen molecule at 27 ^{o}C. Atomic mass of oxygen is 16.

24. A balloon is ascending at the rate of 4.9 m/s. A packet is dropped from the balloon when situated at a height of 245 m. How long does it take the packet to reach the ground? What is its final velocity? **[2]**

25. An engine of 100 H. P. draws a train of mass 200 metric ton with a velocity of 36 kmh^{-1}. Find the coefficient of friction. **[2]**

Section C

26. In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state A to B via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in the latter case? (Take 1 cal = 4.19 J) **[3]**

27. Briefly explain the cause of friction. **[3]**

28. The manual of a car instructs the owner to inflate the tyres to a pressure of 200 kPa. **[3]**
    i. What is the recommended gauge pressure?
    ii. What is the recommended absolute pressure?
    iii. If after the required inflation of the tyres, the car is driven to a mountain peak where the atmospheric pressure is 10% below that at sea level, what will the tyre gauge read?

OR

Explain why?

a. The blood pressure in humans is greater at the feet than the brain.
b. Atmospheric pressure at a height of about 6 km decreases to nearly half its value at the sea level through the height of the atmosphere is more than 100 km.
c. Hydrostatic pressure is a scalar quantity even though the pressure is force divided by area.

29. A SONAR system fixed in a submarine operates at a frequency 40.0 kHz. An enemy submarine moves towards the SONAR with a speed of 360 km h^{-1}. What is the frequency of sound reflected by the submarine? Take the speed of sound in water to be 1450 ms^{-1}. **[3]**

OR

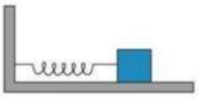
A wave travelling along a string is described by y(x ,t) = 0.005sin(80.0x -3.0t) in which the numerical constants are in SI units (0.005 m, 80.0 rad m^{-1} and 3.0 rad s^{-1}). Calculate

a. the amplitude of particle,
b. the wavelength and
c. the period and frequency of the wave. Also, calculate displacement y of the particle at a distance x = 30.0 cm and time t = 20s?

30. Briefly explain the formation of trade wind. **[3]**

Section D

31. A spring having with a spring constant 1200 N m^{-1} is mounted on a horizontal table as shown in Fig. A mass of 3 kg is attached to the free end of the spring. The mass is then pulled sideways to a distance of 2.0 cm and released. **[5]**



Determine

i. the frequency of oscillations,
ii. maximum acceleration of the mass, and
iii. the maximum speed of the mass.

OR

The motion of a particle executing simple harmonic motion is described by the displacement function, $x(t) = A\cos(\omega t + \phi)$ If the initial (t = 0) position of the particle is 1 cm and its initial velocity is ω cm /s, then what are its amplitude and initial phase angle? The angular frequency of the particle is π s^{-1}. If instead of the cosine function, we choose the sine function to describe the SHM, $x = B\sin(\omega t + \phi)$, then what are the amplitude and initial phase of the particle with the above initial conditions?

32. State parallelogram law of vector addition. Show that resultant of two vectors $\vec{A}$ and $\vec{B}$ inclined at an angle θ is $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$ **[5]**

OR

A bird is at a point P whose coordinates are (4m ,-1m, 5m). The bird observes two points P_1 and P_2 having coordinates (-1 m, 2 m, 0 m) and (1 m, 1 m, 4 m) respectively. At time t = 0, it starts flying in a plane of three positions, with a constant speed of 5ms^{-1} in a direction perpendicular to the straight line P_1P_2 till it sees P_1 and P_2 collinear at time t. Calculate t.

33. A car weighs 1800 kg. The distance between its front and back axles is 1.8 m. Its centre of gravity is 1.05 m behind the front axle. Determine the force exerted by the level ground on each front wheel and each back wheel. **[5]**

OR

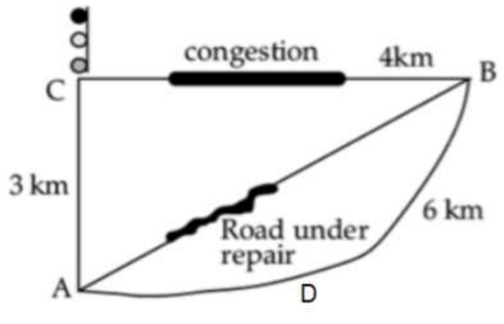
A solid cylinder rolls up an inclined plane of angle of inclination 30°. At the bottom of the inclined plane the centre of mass of the cylinder has a speed of 5 m/s.

a. How far will the cylinder go up the plane?
b. How long will it take to return to the bottom?

Section E

34. **Read the text carefully and answer the questions:** **[4]**

Tabu lives at A. He was supposed to do to his uncle's house at B. A and B is connected by a straight road 5 km long. But that day the road was under repair. So, all the buses were following a diversion via C. A to B via C is 7 km. Moreover, this route is congested There is a traffic signal at C also.



Tabu got a seat just behind the driver. He noticed that the minimum reading on the speedometer was 15km/h. But ultimately the bus took 1 hour to each B. He could not understand the fallacy.

(i) What is the distance and displacement of Tabu?

(ii) Why the speedometer reading was minimum 15 km/h, but actual time required to cover 7 km was 1 hour?

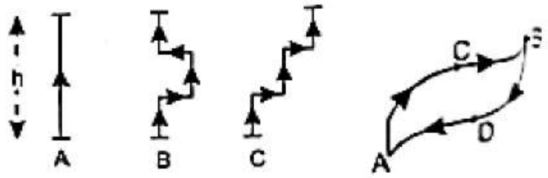
(iii) If the bus followed ADB path and reached B to (1 hour, find the average speed of the bus.

OR

Which of the following graphs represents the motion of the bus if it covers AC distance at a speed 15 km/h and CB distance at a speed 20 km/h and total distance is covered in 1 hour including halt at traffic signal?

35. **Read the text carefully and answer the questions:** **[4]**

In nature we have various types of forces. A force is said to be a conservative force if work done by (or against) the force for moving an object from one position to another position depends on these two initial and final) points but is independent of other factors like the nature of path followed or velocity of object. It is also found that work done on an object against the conservative force present there gets stored up as the potential energy of the object. When external constraints are removed, the stored potential energy manifests itself as kinetic energy. lf above mentioned conditions are not fulfilled then force is called a non-conservative force.



(i) Give two examples of conservative forces.

(ii) Three girls of same mass climb through a certain height h' following different paths shown as A, B and C in the figure. In which case is the work done against gravity maximum and in which case it is minimum?

(iii) An object is taken from position A to B via a path ACB and then brought back to position A via another path BDA. If the force involved is a conservative force, then show that net work done for entire closed path is zero.

OR

What is a non conservative force? Give two examples

Solution

SAMPLE PAPER - 6

Class 11 - Physics

Section A

1. **(a)** 9.8 m

   Explanation: 1 Ls^{-2} = 9.8 ms^{-2} or L = 9.8 m

2. **(a)** only ii

   Explanation: The efficiency of engine is given by $\eta = \frac{\text{output power}}{\text{input power}} \times$ 100 %

   Here, P_{output} = 10 kW P_{output} = 2 × 10^3 cal/g × 1 g/s

   = 2 × 10^3 cal/s

   = 2 × 10^3 × 4.2J/s

   = 8.4 kW

   As, P_{output} > P_{input}, hence it is never possible.

3. **(d)** $\frac{3}{4}j$

   Explanation: $\tau = \frac{dL}{dt}$

   $= \frac{4J - J}{4} = \frac{3}{4}J$

4. **(a)** Length = 50 cm, diameter = 0.5 mm

   Explanation: $\Delta l = \frac{Fl}{AY} = \frac{Fl}{\left(\frac{\pi d^2}{4}\right)Y}$ or $(\Delta l) \propto \frac{l}{d^2}$

   Now, $\frac{l}{d^2}$ is maximum in option (a).

5. **(a)** KE

   Explanation: When a body is orbiting the earth, the centripetal acceleration is provided by the gravitational force of attraction from earth.

   $\Rightarrow \frac{GMm}{R^2} = \frac{mv^2}{R}$

   $\Rightarrow$ KE = $\frac{mv^2}{2} = \frac{GMm}{2R}$

   The gravitational potential energy = PE = $-\frac{GMm}{R}$

   Hence the total energy = PE + KE = $-\frac{GMm}{R}$

   Therefore the energy that must be provided to the body to completely escape from its orbit = $\frac{GMm}{2R}$ = KE

6. **(d)** $\frac{nKT}{2}$

   Explanation: Mean energy of gas per degree of freedom $= \frac{1}{2}$kT

   Where k is the Boltzmann constant.

   Thus mean energy of gas with n degrees of freedom $= \frac{n}{2}kT$

7. **(d)** 20K

   Explanation: work done, W = 830 J

   No. of moles of gas, μ = 2

   For diatomic gas γ = 1.4

   Work done during an adiabatic change

   W = $\frac{\mu R(T_1 - T_2)}{\gamma - 1}$

   $\Rightarrow$ 830 = $\frac{2 \times 8.3(\Delta T)}{1.4 - 1} = \frac{2 \times 8.3(\Delta T)}{0.4}$

   $\Rightarrow \Delta T$ = $\frac{830 \times 0.4}{2 \times 8.3}$ = 20K

8. **(b)** 65

   Explanation: Let the frequency of first fork be n. Then, the frequency of last fork is 2n. Since, the successive tuning fork gives four beats, then Frequency of first fork = n

   Frequency of second fork = n + 4

   Frequency of third fork = n + 8 = n + 2 × 4

Frequency of Nth fork = n + (N - 1)4

As Nth fork is the last fork. So,

2n = n + (N - 1)4

or n = (N - 1)4 or 256 = (N - 1)4

$\therefore$ N = 65

9. **(a)** $N^{\frac{1}{3}}$

Explanation: When a droplet of radius R is broken into N small droplets total volume will remain constant. Let the radius of small droplets be r. Then

$\frac{4}{3}\pi R^3 = N\frac{4}{3}\pi r^3$

$r = \frac{R}{N^{\frac{1}{3}}}$

work done will be equal to the change in surface energy, thus

W = $S_f - S_i = N4\pi r^2 T - 4\pi R^2 T$

W = $N4\pi\left(\frac{R}{N^{\frac{1}{3}}}\right)^2 T - 4\pi R^2 T$

W = $4\pi R^2 T\left(N^{\frac{1}{3}} - 1\right)$

if $N^{\frac{1}{3}}$ is very large thus it becomes

W = $4\pi R^2 T N^{\frac{1}{3}}$

thus

$W \propto N^{\frac{1}{3}}$

10. **(d)** P_4

Explanation: Here, angular momentum is conserved. According to it

$I_1\omega_1 = I_2\omega_2$

or $MR_1^2\omega_1 = MR_2^2\omega_2$ or $R_1v_1 = R_2v_2$

At the point P_4, the value of R is minimum and hence velocity is maximum or KE is maximum.

11. **(d)** 158.31 Nm

Explanation: Given that,

ω = 3600 rpm

ω = 3600 rpm

= $\frac{3600}{60} \times 2\pi$ rds^{-1}

P = 80 HP

= 80 $\times$ 746 W

= 59680 Nms^{-1}

As we know that,

P = $\tau\omega$

So, $\tau = \frac{P}{\omega}$

Put the value, we have

$\tau = \frac{59680}{120\pi}$

So, τ = 158.30611 NM

12. **(c)** 2v

Explanation: Root mean square speed, v_{rms} = = $\sqrt{\frac{3RT}{M}}$

Since, M remains the same

$\therefore v_{\mathrm{rms}} \propto \sqrt{T}$

$\therefore \frac{(v_{\mathrm{rms}})_1}{(v_{\mathrm{rms}})_2} = \sqrt{\frac{T_1}{T_2}}$

$\therefore \frac{v}{(v_{\mathrm{rms}})_2} = \sqrt{\frac{120\mathrm{K}}{480\mathrm{K}}} = \frac{1}{2}$ [$\because$ $(v_{rms})_1$ = v (Given)]

or (v_{rms}) = 2v

13. **(d)** $y = a \cos[(\omega - kv)t - kx_0]$

Explanation: Suppose at an instant t, x-coordinate of a point with reference to moving frame is x_0. Since, at this moment, origin of moving frame is at distance vt from origin of the fixed reference frame, therefore, the actual x-coordinate of the point will be equal to $(vt + x_0)$.

Putting this value of x in the given equation, we get;

$y = a \cos[(\omega t - k(vt + x_0)]$

$= a \cos[(\omega - kv)t - kx_0]$

14. **(c)** More than 0.5

Explanation: As we know that,

PV^{γ} = constant

$TV^{\gamma-1}$ = constant

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$\left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{T_1}{T_2}$

$\frac{V_2}{V_1} = \left(\frac{T_1}{2T_1}\right)^{\frac{1}{\gamma-1}}$ $[\because T_2 = 2T_1]$

$= \left(\frac{1}{2}\right)^{\frac{1}{\gamma-1}}$

Hence ratio will be more than $\frac{1}{2}$.

15. **(d)** $\omega^2 R$

Explanation: Acceleration due to gravity at a place of latitude X due to the rotation of the earth is:

$g' = g - R\omega^2 \cos^2\lambda$

At equator: $\lambda = 0°$, $\cos 0° = 1$

$\therefore g' = g_e$ $[g_e = g - R\omega^2]$

At poles: $\lambda = 90°$, $\cos 90° = 0$

$g' = g p$ $[g_p = g]$

$\therefore g_p - g_e = g - (g - R\omega^2) = R\omega^2$

16. **(c)** A is true but R is false.

Explanation: A is true but R is false.

17. **(a)** Assertion and reason both are correct statements and reason is correct explanation for assertion.

Explanation: Assertion and reason both are correct statements and reason is correct explanation for assertion.

18. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation: Unit of quantity $(\frac{L}{R})$ is henry/ohm.

As henry = ohm $\times$ sec,

hence unit of $\frac{L}{R}$ is sec i.e. $[\frac{L}{R}] = [T]$.

Similarly, unit of product CR is farad $\times$ ohm

or, $\frac{\text{coulomb}}{\text{volt}} \times \frac{\text{volt}}{\text{amp}}$ or $\frac{\text{sec} \times \text{amp}}{\text{amp}}$ or, sec

i.e. [CR] = [T] therefore $[\frac{L}{R}]$ and [CR] both have the same dimensions.

Section B

19. i. 4

Explanation: Significant figure- 2, 3, 7, 0. Trailing 0's are significant. These 0's increase the accuracy of the answer.

ii. 4

Explanation: Significant figure- 6, 3, 2, 0. Trailing 0's are significant. These 0's increase the accuracy of the answer.

20. Impulse of a force is defined as the product of force and the time for which force is acting. According to impulse-momentum theorem, the impulse of a force in a given time is equal to the total change in momentum of the object during that time.

21. The moon can escape only if the moon has no orbital motion. In fact, while revolving around the earth, the moon has orbital motion around the sun also. The gravitational attraction of the sun on the moon provides the centripetal force required for the orbital motion around the sun.

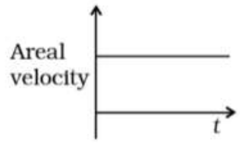
OR

According to Kepler's second law, the line between the sun and the planet sweeps equal area in equal interval of time, i.e.

$\frac{\Delta A}{\Delta t} = K$

Where $\frac{\Delta A}{\Delta t}$ is the areal velocity of any planet and K is any constant

Therefore, areal velocity remains constant and is independent of time. The graph between areal velocity versus time for mars is as shown



22. given $\Rightarrow$ change in length $\triangle L = x$

youngs's modulus is given by Y $= \frac{\text{stress}}{\text{streching}} = \frac{P \times L}{A \times \triangle L}$

Restoring force $F = \frac{YAx}{L}$

Work done in streching the wire by amount, dx

dW = F.dx

Total work done in streching the wire from 0 + x

$W = \int dW = \int_0^x F dx = \int_0^x \frac{YAx}{L} dx = \frac{YA}{L}\left[\frac{x^2}{2}\right]_0^x$

$W = \frac{YAx^2}{2L}$

23. The mean free path is the average distance travelled by a moving particle between successive collisions with the particles, which modify its direction or energy or other particle properties. factors depend on mean free path:
    i. radius of the molecule (size of the molecule)
    ii. Pressure
    iii. Temperature
    iv. Density

OR

Here T = 27 ^{0}C = 300 K and atomic mass of oxygen = 16. Since oxygen is a diatomic gas, hence its molar mass $M_0 = 2 \times 16 = 32$ g $= 32 \times 10^{-3}$ kg

$\therefore$ rms speed of oxygen molecule v $= \sqrt{\frac{3RT}{M_0}}$

$= \sqrt{\frac{3 \times 8.31 \times 300}{32 \times 10^{-3}}}$

$= 483.4$ ms$^{-1} \cong 5 \times 10^5$ ms^{-1}

24. According to the question

u = 4.9m/s (upward)

height at which packet is released h = 245 m

For packet, acceleration, a = g = 9.8m/s^2

According to second equation of motion

$h = ut + \frac{1}{2}gt^2$

$245 = -4.9 \times t + \frac{1}{2}(9.8) \times t^2$

$4.9t^2 - 49t = 245$

solving the above equation

we get

t = 7.6 s or -5.6 s Since time cannot be negative

$\therefore$ t = 7.6s

Now $v = u + gt$

v = -4.9 + (9.8)(7.6)

$v = 69.58$ m/s

25. Power of engine,

P = 100 H.P. = 100 $\times$ 746 = 74600 W

Velocity, v = 36 km h^{-1} = 10 ms^{-1}

If the frictional force overcome by the engine is F, then

P = F $\times$ v or $F = \frac{P}{v} = \frac{74600}{10}$ = 7460 N

Normal reaction,

R = mg = 200 × 1000 × 9.8 N

Coefficient of friction,

$\mu = \frac{F}{R} = \frac{7460}{200 \times 1000 \times 9.8}$ = 0.0038

Section C

26. The work done (W) in changing the state of system from A to B = 22.3 J.

In adiabatic process there is no exchange of heat.

$\therefore \Delta Q = 0$

ΔW = -22.3 J (negative sign is due to work is done on the system)

From the first law of thermodynamics

$\Delta Q = \Delta U + \Delta W$

Where,

ΔU = Change in the internal energy of the gas

ΔW = work done

$\therefore \Delta U = \Delta Q - \Delta W$ = 0- (- 22.3) = 22.3 Joule

The net heat absorbed by the system

ΔQ = 9.35 calory = 9.35 × 4.19 = 39.1765 Joule

Heat absorbed, $\Delta Q = \Delta U + \Delta W$ (by first law of thermodynamics)

$\therefore \Delta W = \Delta Q - \Delta U$

= 39.1765 - 22.3

= 16.8765 Joule

Therefore, 16.88 Joule of work is done by the system in changing the state.

27. Every object has a rough surface, though the surface may appear to be smooth to the naked eyes. When we see through the microscope, it is found that the surface of all the objects has rough edges. When something (say A) is placed on the body (say B), the irregularities of two bodies are interlocked and at such points of interlocking (i.e., points of actual contacts of two bodies) atomic and molecular forces of attraction are acting. When body A tends to move over the surface of B, these intermolecular forces try to oppose the motion. In fact, the pressure at the points of actual contact is B very high and a type of cold welding takes place. Due to the motion of body A over B, the bonds between the molecules are continuously broken and new bonds are formed at other points. Friction is on account of the force needed to break these molecular bonds.

Hence, the friction is caused by the interlocking of irregularities in the surfaces of two objects which are in contact with each other.

28. i. Recommended gauge pressure = Pressure recommended in the manual P_g = 200kPa.

ii. Recommended absolute pressure $P = P_a + P_g$ = 101 kPa + 200 kPa = 301 kPa.

[$\therefore$ Atmospheric pressure $P_a = 1.01 \times 10^5$ Pa = 101 kPa]

iii. At the mountain peak the atmospheric pressure is 10% below that at sea level, hence new atmospheric pressure

$P'_a = \frac{90}{100} \times 101$ kPa = 91 kPa.

Presuming that the absolute pressure in the tyre has not changed during the drive, the new gauge pressure

$P'_g = P - P'_a$ = 301 kPa - 91 kPa = 210 kPa.

OR

a. The pressure of the liquid column is given by p = hρg, where h is depth, ρ is density and g is the acceleration due to gravity. The pressure of the liquid column increases with depth. The height of the blood column in the human body is more at feet than at the brain, that is why the blood exerts more pressure at the feet than at the brain.

b. The atmospheric pressure at a height of about 6 km decreases to nearly half of its value at the sea level because the density of air is maximum near the surface of the earth and decreases rapidly with height. At a height of 6 km, the density of air decreases to nearly half of its value at the sea level. Beyond 6 km height, the density of air decreases very slowly with height.

c. Hydrostatic pressure is a scalar quantity because when force is applied on a liquid, the pressure is transmitted equally in all directions inside the liquid. Therefore, it has no fixed direction.

29. Operating frequency of the SONAR system, v = 40 kHz

Speed of the enemy submarine, v_e = 360 km/h = 100 m/s

Speed of sound in water, v = 1450 m/s

The source is at rest and the observer (enemy submarine) is moving toward it. Hence, the apparent frequency (v') received and reflected by the submarine is given by the relation:

$\Rightarrow v' = \left(\frac{v+v_e}{v}\right) v$

$= \left(\frac{1450+100}{1450}\right) \times 40 = 42.76kHz$

The frequency (v") received by the enemy submarine is given by the relation:

$\Rightarrow v'' = \left(\frac{v}{v+v_s}\right) v'$

Where, v_s = 100m/s

So, frequency of sound received is:

$\Rightarrow v'' = \left(\frac{1450}{1450-100}\right) \times$ 42.76 = 45.93 kHz

OR

Given, y(x ,t) = 0.005 sin(80.0x - 3.0t) m .....(i)

We know the general form of the equation of an SHM as, y(x, t) = a sin(kx - ωt) .....(ii)

Now, comparing the given equation (i) with the general equation (ii) we get,

a = 0.005 m (amplitude)

k = 80.0 rad/m (a wave number)

ω = 3.0 rad/s (angular frequency)

The physical quantities by using the given fundamental physical quantities.

a. Amplitude is given by, a = 0.005 m = 5 mm
b. Wavelength is given by, $\lambda = \frac{2\pi}{k} = \frac{2\pi}{80}$ = 7.85 cm
c. Time period is given by, T = $2\pi/\omega = \frac{2\pi}{3}$ =2.09 s

   and frequency is given by, $\nu = \frac{1}{T} = \frac{1}{2.09}$

   = 0.478 $\simeq$ 0.48Hz

   Now, the displacement y of the particle at a distance is given by;

   x = 30.0 cm = 0.3 m and time t = 20 s

   y(0.3, 20) = 0.005 sin (80 $\times$ 0.3 - 3.0 $\times$ 20)

   y (0.3, 20) = 0.005 sin (24 - 60)

= -0.005 sin(36)

= -0.00495 m $\simeq$ - 5 mm

30. Trade winds are steady surface winds on the earth due to the natural convection phenomenon. The equatorial and polar regions of the earth receive unequal solar heat. The equatorial region receives more heat than the polar region. So air at the earth's surface near the equator is hotter than the air in the upper atmosphere of the poles, due to which a convection current would be set up, with the hot air at the equatorial surface rising and moving out towards the poles and in turn, colder air at poles descending and streaming in towards the equator. Because of earth's rotation about its own axis, the air close to the equator region has an eastward speed of 1600 km h^{-1}, while it is zero close to the polar region. As a result, the hot air from the equator descends not at the poles but at 30^o N latitude and returns to the equator. So in this way trade winds are formed.

Section D

31. In mechanics and physics, Simple Harmonic Motion is a special type of periodic motion or oscillation motion where the restoring force is directly proportional to the displacement and acts in the direction opposite to that of displacement.

Spring constant, k = 1200 N m^{-1}

Mass, m = 3 kg

Displacement, A = 2.0 cm = 0.02 cm

i. Frequency of oscillation v, is given by the relation:

   $v = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

   Where T is the time period

   $\therefore v = \frac{1}{2\times 3.14}\sqrt{\frac{1200}{3}} = 3.18\text{m/s}$

   Hence, the frequency of oscillations is 3.18 cycles per second.

ii. Maximum acceleration (a) is given by the relation:

   $a = \omega^2 A$

   Where,

   ω = Angular frequency = $\sqrt{\frac{k}{m}}$

A = Maximum displacement

$\therefore a=\frac{k}{m}A=\frac{1200\times 0.02}{3}=8ms^{-2}$

Hence, the maximum acceleration of the mass is 8.0 m/s^2.

iii. Maximum velocity, $v_{\max}=A\omega$

$=A\sqrt{\frac{k}{m}}=0.02\times\sqrt{\frac{1200}{3}}=0.4\mathrm{m/s}$

Hence, the maximum velocity of the object is 0.4 m/s at its mean position i.e at x = 0.

OR

Given, displacement equation x(t) = Acos($\omega t+\phi$) ...(i)

At t = 0; x(0) = 1 cm, velocity of the particle v = ωcm/s

Angular frequency $\omega=\pi$ s^{-1}

$\Rightarrow 1=A\cos(\omega t+\phi)$

For t = 0, 1 = A cosϕ..........(i)

Now, $v(t)=\frac{dx(t)}{dt}=\frac{d}{dt}A\cos(\omega t+\phi)$

$=-A\omega\sin(\omega t+\phi)$

Again at t = 0, $v=\omega$ cm/s

$\Rightarrow\omega=-A\omega\sin\phi$

$\Rightarrow -1=A\sin\phi$ ....(ii)

Squaring and adding eqs.(i) and (ii),

$A^2\cos^2\phi+A^2\sin^2\phi=(1)^2+(-1)^2$

$A^2=2\Rightarrow A=\pm\sqrt{2}\mathrm{cm}$

Hence, the amplitude of the SHM = $\sqrt{2}$ cm

Dividing Eq. (ii) by (i), we get

$\frac{A\sin\phi}{A\cos\phi}=\frac{-1}{1}$ or $\tan\phi=-1$

$\Rightarrow\phi=-\frac{\pi}{4}$ or $\frac{7\pi}{4}$

Now, if instead of cosine, we choose the sine function in the displacement equation, then

x(t) = B sin($\omega t+\alpha$)

At t = 0, x = 1 cm, $\Rightarrow 1=B\sin(0+\alpha)$

or $B\sin\alpha=1$ ....(iii)

Velocity v(t) = $\frac{dx(t)}{dt}=\frac{d}{dt}[B\sin(\omega t+\alpha)]$

$=+B\omega\cos(\omega t+\alpha)$

Again at t = 0, v(t) = ω cm/s

B cosα = + 1..............(iv)

Squaring and adding Eqs.(iii) and (iv),

$B^2\sin^2\alpha+B^2\cos^2\alpha=(1)^2+(+1)^2$

$\Rightarrow B^2\sin^2\alpha+B^2\cos^2\alpha=2$

$B^2\left(\sin^2\alpha+\cos^2\alpha\right)=2$

$B^2 1=2\Rightarrow B=\pm\sqrt{2}\mathrm{cm}$

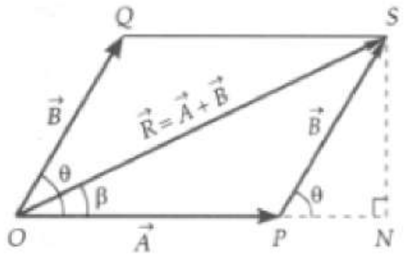
Hence, amplitude of the simple harmonic motion in both types of trigonometric wave equation expression = $\sqrt{2}$ cm

Dividing Eq. (iii) by (iv), we get

$\frac{B\sin\alpha}{B\cos\alpha}=\frac{1}{1}$ or $\tan\alpha=1$

$\therefore\alpha=\frac{\pi}{4}$, only the phase angle differs for sine and cosine wave equation.

32. Let the two $\vec{A}$ and $\vec{B}$ inclined to each other at an angle θ be represented both in magnitude and direction by the adjacent sides $\overrightarrow{OP}$ and $\overrightarrow{OQ}$ of the parallelogram OPSQ. Then according to the parallelogram law of vector addition, the resultant of $\vec{A}$ and $\vec{B}$ is represented both in magnitude and direction by the diagonal $\overrightarrow{OS}$ of the parallelogram.

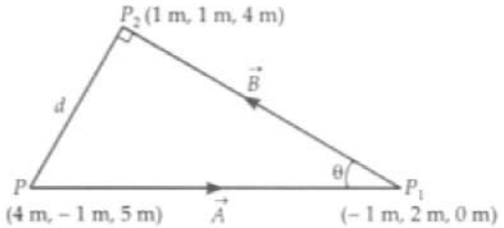


Analytical treatement of parallelogram law.

Magnitude of resultant $\vec{R}$. Draw SN perpendicular to OP produced.
Then $\angle SPN = \angle QOP = \theta$, OP = A, PS = OQ = B, OS = R
From right angled ΔSNP, we have
$\frac{SN}{PS} = \sin\theta$ or SN = PS sinθ = B sinθ
and $\frac{PN}{PS} = \cos\theta$ or PN = PQ cos θ = B cos θ
Using Pythagoras theorem in right angled ΔONQ,
We get
$OQ^2 = ON^2 + QN^2$
$= (OP + PN)^2 + QN^2$
or $R^2 = (A + B\cos\theta)^2 + (B\sin\theta)^2$
$= A^2 + B^2\cos^2\theta + 2AB\cos\theta + B^2\sin^2\theta$
$= A^2 + B^2(\cos^2\theta + \sin^2\theta) + 2AB\cos\theta$
$= A^2 + B^2 + 2AB\cos\theta$
or $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

OR

The situation is shown in figure. The bird flies in a direction perpendicular to line P_1 P_2. Suppose it reaches the point Q in time t (after starting from point P) where it sees P_1 and P_2 as collinear.



Let $\overrightarrow{PP_1} = \vec{A}$, $\vec{P}_1\vec{P}_2 = \vec{B}, \angle PP_1P_2 = \theta$ and PQ = d
As $|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$
$\therefore \quad \sin\theta = \frac{|\vec{A}\times\vec{B}|}{|\vec{A}||\vec{B}|}$
Now $\vec{A} = (-1-4)\hat{i} + (2+1)\hat{j} + (0-5)\hat{k}$
But $\vec{A} = (-1-4)\hat{i} + (2+1)\hat{j} + (0-5)\hat{k}$
$= -5\hat{i} + 3\hat{j} - 5\hat{k}$
and $\vec{B} = (1+1)\hat{i} + (1-2)\hat{j} + (4-0)\hat{k}$
$= 2\hat{i} - \hat{j} + 4\hat{k}$

$$\therefore \quad \vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -5 & 3 & -5 \\ 2 & -1 & 4 \end{vmatrix}$$

$= (12-5)\hat{i} + (-10+20)\hat{j} + \hat{k}(5-6)$
$= 7\hat{i} + 10\hat{j} - \hat{k}$
$\therefore |\vec{A}\times\vec{B}| = \sqrt{7^2 + 10^2 + 1^2} = 12.25\ \text{m}^2$
and $|\vec{B}| = \sqrt{2^2 + 1^2 + 4^2}$ = 4.583 m
$\therefore \quad d = \frac{12.25}{4.583}$ = 2.67 m

Time taken by bird to reach the point Q will be

$t = \frac{d}{v} = \frac{2.67}{5} = 0.5346$ s

33. Weight of car = 1800 Kg

Distance of COG from front axle = 1.05 m

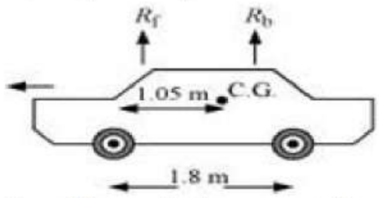
Distance of COG from back axle = 1.8 - 1.05 = 0.75 m

Vertical forces are balanced ,

So,At translational equilibrium:

$R_1 + R_2 = mg$

$R_1 + R_2 = 1800 \times 9.8 = 17640$



R_1 and R_2 are the forces exerted by the level ground on the front and back wheels respectively.

Angular momentum about centre of gravity is zero.

So,

R1(1.05) = R2(1.8 - 1.05)

$R_1 \times 1.05 = R_2 \times 0.75$

$\frac{R_1}{R_2} = \frac{0.75}{1.05} = \frac{5}{7}$

$\frac{R_1}{R_2} = \frac{7}{5}$

$R_1 = 1.4 R_2$ .....(ii)

Solving equations (i) and (ii), we get:

$1.4 R_2 + R_2 = 17640$

$R_2 = \frac{17640}{2.4} = 7350$N

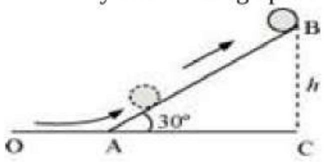
$\therefore R_1 = 17640 - 7350 = 10290$ N

Therefore, the force exerted on each front wheel $= \frac{R_1}{2} = \frac{7350}{2} = 3675N$, and

The force exerted on each back wheel $= \frac{R_2}{2} = \frac{10290}{2} = 5145N$

OR

A solid cylinder rolling up an inclination is shown in the following figure.



Initial velocity of the solid cylinder, v = 5 m/s

Angle of inclination, $\theta = 30^\circ$

Height reached by the cylinder = h

a. Energy of the cylinder at point A will be purely kinetic due to the rotation and translational motion. Hence, total energy at A

   $= KE_{rot} + KE_{trans}$

   $= \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$

   The energy of the cylinder at point B will be purely in the form of gravitational potential energy = mgh

   Using the law of conservation of energy, we can write:

   $\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = mgh$

   Moment of inertia of the solid cylinder, $I = \frac{1}{2}mr^2$

   $\therefore \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2 + \frac{1}{2}mv^2 = mgh$

   $\frac{1}{4}I\omega^2 + \frac{1}{2}mv^2 = mgh$

   But we have the relation, $v = r\omega$

   $\therefore \frac{1}{4}v^2 + \frac{1}{2}v^2 = gh$

   $\frac{3}{4}v^2 = gh$

$\therefore h=\frac{3}{4} \frac{v^2}{g}$

$=\frac{3}{4} \times \frac{5 \times 5}{9.8}=1.91 \mathrm{m}$

To find the distance covered along the inclined plane

In ΔABC:

$\sin \theta=\frac{BC}{AB}$

$\sin 30^{\circ}=\frac{h}{AB}$

$AB=\frac{1.91}{0.5}=3.82 \mathrm{m}$

Hence, the cylinder will travel 3.82 m up the inclined plane.

b. $v=\left(\frac{2gh}{1+\frac{K^2}{R^2}}\right)^{\frac{1}{2}}$

$\therefore v=\left(\frac{2gAB \sin \theta}{1+\frac{K^2}{R^2}}\right)^{\frac{1}{2}}$

For the solid cylinder, $K^2=\frac{R^2}{2}$

$\therefore v=\left(\frac{2gAB \sin \theta}{1+\frac{1}{2}}\right)^{\frac{1}{2}}$

$=\left(\frac{4}{3} gAB \sin \theta\right)^{\frac{1}{2}}$

The time taken to return to the bottom is:

$t=\frac{AB}{v}$

$=\frac{AB}{\left(\frac{4}{3} gAB \sin \theta\right)^{\frac{1}{2}}}=\left(\frac{3AB}{4g \sin \theta}\right)^{\frac{1}{2}}$

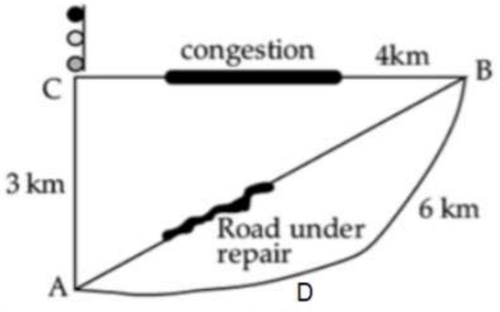
$=\left(\frac{11.46}{19.6}\right)^{\frac{1}{2}}=0.7645$

So the total time taken by the cylinder to return to the bottom is (2×0.764)= 1.53 s.as time of ascend is equal to time of descend for the following problem.

Section E

34. **Read the text carefully and answer the questions:**

Tabu lives at A. He was supposed to do to his uncle's house at B. A and B is connected by a straight road 5 km long. But that day the road was under repair. So, all the buses were following a diversion via C. A to B via C is 7 km. Moreover, this route is congested There is a traffic signal at C also.



Tabu got a seat just behind the driver. He noticed that the minimum reading on the speedometer was 15km/h. But ultimately the bus took 1 hour to each B. He could not understand the fallacy.

(i) Distance is the actual path covered ic., 3 + 4 = 7 km.

Displacement is the straight line distance from A to B i.e., $\sqrt{3^2+4^2}$ = 5 km.

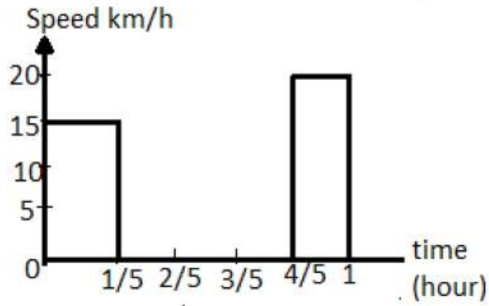
(ii) Halt timing at the traffic signal, slow speed at the congested areas and halt-timing at the bus stops are also to be taken into account.

(iii)Average speed = $\frac{\text{Total distance traversed}}{\text{Total time taken}}$

= $\frac{6}{1}$ = 6 km/h

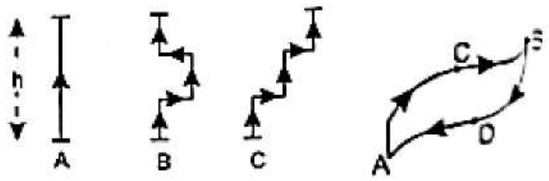
OR

Following graph shows the required v-t graph.



35. **Read the text carefully and answer the questions:**

In nature we have various types of forces. A force is said to be a conservative force if work done by (or against) the force for moving an object from one position to another position depends on these two initial and final) points but is independent of other factors like the nature of path followed or velocity of object. It is also found that work done on an object against the conservative force present there gets stored up as the potential energy of the object. When external constraints are removed, the stored potential energy manifests itself as kinetic energy. If above mentioned conditions are not fulfilled then force is called a non-conservative force.



(i) Gravitational force, force of gravity and elastic force in a spring are example of Conservative forces.

(ii) Work done by all the three girls is exactly the same (w = mgh), because the force of gravity is a conservative force So work done does not depend on the nature of the path

(iii)Work done to take an object from position A to B via path ACB and path ADB will be exactly the same if the force involved is a conservative force. $W_{ACB} = W_{ADB}$ It is also clear that work done to take the object from position B to position A via path BDA will be: $W_{BDA} = -W_{ADB}$. Total work done for entire closed path BDA

$W = W_{ACB} + W_{BDA} = W_{ADB} - W_{ADB} = \text{ZERO}$

OR

A force is said to be non-conservative if work done by/against it for moving an object from one position to another depends on the nature of path followed besides the two positions. Moreover, work done against a non-conservative force is never stored as potential energy but is dissipated as heat energy. Friction and viscous force are examples of non conservative forces.