TOCAB
INSTITUTIONS
PITAMPURA, DELHI-34
Ph.: 27010428, 27034838

TOCAB *Classes*

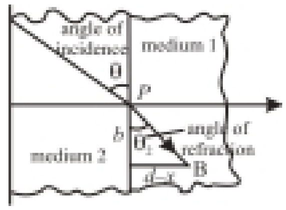
PHYSICS
(IIT Model Test Paper - 1)

www.etocab.org
● VIVEK VIHAR
Ph.: 22141188, 22141199
● MAYUR VIHAR Phase-I

IIT-NR - 1

INSTRUCTIONS:
Read the following passage (A) to (F) and answer the multiple choice questions based on each passage.

Passage (A)



The speed of light depends on the medium through which it travels and trends to be slower in denser media. In a vacuum, it travels at the famous speed $c = 3 \times 10^8$ m/s, but in the earth's atmosphere it travels slightly slower than that, and in glass slower still (about two-thirds as fast). Fermat's principle in optics states that light travels from one point to another along the quickest route. This observation enables us to predict the path light will take when it travels from a point in one medium (air, say) to a point in another medium (say, glass or water).

Let us find the path that a ray of light will follow in going from a point A in a medium where the speed of light is c1 across a straight boundary to point B in a medium where the speed of light is c_2.

Solution: Since light travelling from A and B will do so by the quickest route, we look for a path that will minimize the travel time. Assume that A and B lie in the *xy*-plane and that the line separating the two media is the *x*-axis. In a uniform medium, were the speed of light remains constant, 'shortest time' means consist of a line segment from A to a boundary point P, followed by another line segment from P to B. From the formula distance equal rate times time. We have time $= \frac{\text{distance}}{\text{rate}}$. The time required for light to travel from A and P is therefore.

$$t_1 = \frac{AP}{c_1} = \frac{\sqrt{a^2 + x^2}}{c_1}.$$

From P and B the time is $t_2 = \frac{PB}{c_2} = \frac{\sqrt{b^2 + (d-x)^2}}{c_2}$

The time from A and B is the sum of these

$$t = t_1 + t_2 = \frac{\sqrt{a^2 + x^2}}{c_1} + \frac{\sqrt{b^2 + (d-x)^2}}{c_2}$$

Equation expresses t as a differentiable function of x whose domainis $[0, d]$, and we want to find the absolute minimum value of t on this closed interval. We find

$$\frac{dt}{dx} = \frac{x}{c_1\sqrt{a^2 + x^2}} - \frac{(d-x)}{c_2\sqrt{b^2 + (d-x)^2}}$$

In terms of the angle θ_1 and θ_2 in figure,

$$\frac{dt}{dx} = \frac{\sin\theta_1}{c_1} - \frac{\sin\theta_2}{c_2}.$$

We can see from the equation $dt/dx < 0$ at $x = 0$ and $dt/dx > 0$ at $x = d$. Hence $dt/dx = 0$ at some point x_0 in between. There is only one such point because dt/dx is an increasing function of x. At this point, $\frac{\sin\theta_1}{c_1} = \frac{\sin\theta_2}{c_2}$

The equation is Snell's law or the law of refraction.

1. From format's principle, we can show that
(a) angle of incident is not equal to angleof reflection
(b) incident ray, reflected ray & normal to the reflectory surface lie in the same plane
(c) light is a wave phenomenon
(d) no change in wavelength takes place in reflection

2. In case of refraction, which we can't prove by using formula principle
(a) ratio of sine of angle of incident to sin of angle of refraction remain a constant and independent of angle of incident
(b) light travels faster in raser medium
(c) refractive index of a substance does not depend upon wavelength
(d) incident ray, refracted ray and normal to the refractory surface remain in same plan.

3. Formet's principle show that $\frac{c_1}{c_2} = \frac{n_1}{n_2} = \frac{\sin\theta_1}{\sin\theta_2}$ for a particular ray or $n \sin\theta =$ constant. Keeping this in mind what will be the path followed by a ray which is travelling through a medium in *xy* plane and whose refractive index is given by $\sqrt{1 + \frac{y}{25}}$ for $y \geq 0$. At a certain moment it passes through P (50, 25) making an angle of 225° with the *x*-axis in anticlockwise direction. Then the path traced by the ray will be a
(a) ellipse (b) straight line
(c) parabola (d) cycloid

4. Choose the correct statement in context of question no: 3
(a) ray will cross x-axis two points
(b) ray will only touch x-axis at origin
(c) ray will cross x-axis at only one point
(d) ray will right touch nor cross x-axis

5. X-axis refractive index can't be expressed by $\sqrt{1 + \frac{y}{25}}$ otherwise certain fundamental behaviour of nature will be violated
(a) light has both particle nature and wavelength
(b) frequency of light does not change in refraction
(c) speed of light is maximum in vacuum
(d) when light is refracted from denser to lighter medium no phase shift take place.

6. In question number 3, if at P (50, 25) the ray is rotated by 90° in anticlockwise direction, then new path followed by the ray will be a curve which can be found by shifting the earlier curve by
(a) 100 unit of the right (b) 50 units of the right
(c) 25 units to the right (d) 50 units to the left

Passage (B)

The acceleration of a body undergoing circular motion with constant speed is entirely radial, directed inward toward the center of rotation. It is given by $a_r = -v^2/r = -rw^2$. Thus, the force producing this acceleration must be given by $F_r = ma_r = -mv^2/r = -mrw^2$ and $F_{theta} = 0$. A simple physical example is a car rounding a curve on a flat (unbanked) road, with the frictional force between the tires and the road providing F_r. The maximum value the frictional force can have before breaking away is $(\mu)_s N = (\mu)_s mg$. Note that it is the static coefficient of friction which is appropriate here. The wheels are rolling in the theta-direction and stationary (instantaneously) in the *r*-direction. So the Newton's Second Law equation is $F_r = -(\mu)_s mg = -mv^2/r$, or $(\mu)_s g = v^2/r$. The equation defines the maximum velocity at a given radius or the minimum radius at a given velocity that the car can have and still negotiate the curve without skidding. On a banked road, F_r can be provided by the component of the normal force exerted on the car by the road in the radial direction. [Remember that the r-axis points away from the center of rotation, not up the bank]. Note that the result (without friction) defines the only value of v^2/r for a given value of the banking angle that the car can have without sliding up or down the bank. For acceleration speed on circular path, note that acceleration will be

$\sqrt{\left(\frac{V^2}{r}\right)^2 + ar^2}$ were ar is rate of charge in speed.

Vectorially $\frac{V^2}{r}$ component of acceleration is perpendicular to a_T.

7. In the passage, what is θ direction ?
(a) parallel to *r* direction (b) parallel to vertical line
(c) tangent to circular path (d) none of these

8. On perfectly smooth and curved road a car is running at a constant speed of V. Radius of the curved portion of the road is say *r*. Then
(a) road must inclined up towards the centre with angle of inclination $\tan^{-1}$
(b) road must incline up towards the centre with angle of inclination $\tan^{-1} v^2/rg$
(c) road must incline down towards the centre of the curved portion with angle of inclination $\tan^{-1} v^2/rg$
(d) none of these

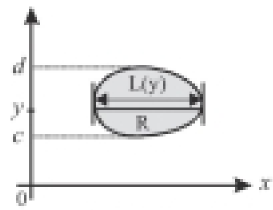
9. A car is running on a rough horizontal curved road whose radius of curvature is *r* for the inner side and R for the outer side. Car is in the middle lane running at maximum possible speed in the lane. Air resistance and necessary centripetal force both are negotiated by the friction present between the car and the road. Then what the car can't do ?
(a) to decrease its speed as long as it remains in the same line
(b) to stop as long it is the on the circular path
(c) is to go into inner lane (d) all these are wrong

10. A bike is moving with speed 10 m/s on a curved road. Air drag is opposing his motion and is roughly a constant at 300 N. Bike can keep going at this speed in a horizontal circular path whose radius must not be less than 25 m. After negotiating the curve it comes to straight road with other conditions same. If brakes are applied to the maximum, in how much time should it come to rest (mass of the bike being 100 kg)
(a) 2 s (b) 1 : 5 s (c) 1 : 25 s (d) 1.05 s

11. Essence of circular motion is that if a body is moving on a curvilinear path it can have two components of acceleration. Along the motion, is a_T and perpendicular to motion is V^2/R. So if a body is moving on a curve $y = 10 \sin \pi x$ with constant speed, the point nearest to the origin which has greatest acceleration will have the co-ordinates as
(a) (10, 1/2) (b) (10, 1)
(c) (1/2, 10) (d) (1, 10)

Passage (C):

Pappus's Theorem for Volumes (Theorem 1)



The region R is to be revolved (once) about the x-axis to generate a solid. A 1700-year old theorem says that the solid's volume can be calculated by multiplying the region's area by the distance travelled by its centroid during the revolution.

If a plane region is revolved once about a line in the plane that does not cut through the region's interior, then the volume of the solid it generates is equal to the region;s area times the distance travelled by the region's centroid during the revolution. If ρ is the distance from the axis of revolution to the centroid, then V = 2πρA. We draw the axis of revolution as the *x*-axis with the region R in the first quadrant. We let *L* (*y*) denote the length of the cross section of R perpendicular to the *y*-axis at *y*. We assue *L* (*y*) to be continuous. By the method of cylindrical shells, the volume of the solid generated by revolving the region about the *x*-axis is

$$V = \int_c^d 2\pi \text{ (shell radius) (shell height) } dy$$

$$= 2\pi \int_c^d yL(y)\, dy \;.................. \; (1)$$

The *y*-co-ordinate of R's centroid is

$$y = \int_c^d \frac{ydA}{A} = \int_c^d \frac{yL(y)\, dy}{A}$$

So that, $\int_c^d yL(y)\, dy = Ay$

Substituting $A\bar{y}$ for the last integral in equation 1 gives $V - 2\pi\bar{y}A$. With ρ equal to $\bar{y}$, we have V = 2πρA.

Pappus's Theorem for the Surface Areas (Theorem 2)

If an arc of a smooth plane curve is revolved once about a line in the plane that does not cut through the arc's interior, then the area of the surface generated by the arc equals the length of the arc times the distance travelled by the arc's centroid during the revolution. If ρ is the distance from the axis of revolution to the centroid then S = 2πρL.

12. In theorem 1, axis or line about which plan is to be rotated has to be
(a) anywhere in the plane of the region
(b) anywhere perpendicular to the plane of the region
(c) anywhere in the plane of the region but it must not cut the region
(d) anyway inclined to the plane of the region

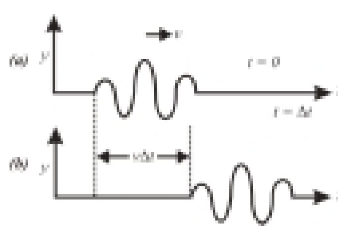
13. In theorem 2, choose the correct option
(a) the arc must be a smooth curve
(b) the line about which the arc is revolved has to be in the plane of the arc.
(c) arc must be revolved only once
(d) all the above are correct

14. A line segment of length l is lying in the x-y plane with one end at the origin and making an angle of θ with x-axis. It is rotated about $x = -a$ by one complete revolution. What will be the area of the surface generated by the line
(a) $(2\pi al + \pi l^2 \cos\theta)$ (b) $\pi al + \frac{\pi l^2}{2}\cos\theta$
(c) $2\pi al + 2\pi l^2 \cos\theta$ (d) none of these

15. Use theorem 1 to find the distance of centroid of semicircle of radius a from the base. We know that if semicircle is rotated about base of one complete revolution it will generate a sphere whose volume is $4/3\ \pi a^3$. Distance of centroid from the base will be
(a) $\frac{3\pi}{4}a$ (b) $\frac{3}{4\pi}a$ (c) $\frac{4}{3\pi}a$ (d) $\frac{2}{3\pi}a$

16. The area of the region R enclosed byn the semiellipse $y = b/a\sqrt{a^2 - x^2}$ and the x-axis is $1/2\ \pi ab$ and the volume of the ellipsoid generated by revolving R about the x-axis is $4/3\ \pi ab^2$. What are the co-ordinate of the centroid of the region
(a) $\frac{4b}{3\pi}, 0$ (b) $0, \frac{4b}{3\pi}$ (c) $0, \frac{2b}{3\pi}$ (d) $0, \frac{b}{\pi}$

Passage (D)



Consider yourself holding one end of a string, the other end being, held tightly by another person so that the string does not sag. If you move the end of the string up and down a few times then a disturbance is created which propagates towards the other end of the string. Thus, if we take a snapshot of the string at $t = 0$, and at a slightly later time Δt, then the snapshot will roughly look like the ones shown in figure a and b. The figures show that the disturbances have identical shapes except for the fact that one is displaced from the other by a distance $v\Delta t$, where v represents the speed of the disturbance. Such a propagation of a disturbance without its change in form is characteristic of a wave.

Referring back to figure a and b, we note that the shape of the string at the instant Δt is similar to its shape at $t = 0$, except for the fact that the whole disturbance has travelled through a certain distance. If v represents the speed of the wave then its distance is simply $v\Delta t$. Consequently, if the equation describing the rope at implies a shift of the origin by a distance vt. Similarly, for a disturbance propagating in the $-x$ direction, if the equation describing the rope at $t = 0$ is $y\ (x)$ then at a later instant t the equation of the curve would be $y\ (x + vt)$.

17. Equation of displacement of particles on x-axis due propagation of wave along positive x-axis with wave speed v be $y = 5 \sin(\pi x)$ at $t = 0$. Then, the particle whose displacement is $5/2$ is at a minimum distance of .... from the origin.
(a) 1 (b) 1/2 (c) 1/6 (d) none

18. If $v = 100$ then at any time t, displacement y will be given by
(a) $y = 5\sin(x - 100)$ (b) $y = 5\sin(\pi x - 100t)$
(c) $y = 5\sin(\pi x - 100\pi t)$ (d) $y = 5\sin(\pi x + 100\pi t)$

19. Particle P (4, 0) will execute SHM with natural frequency, initial phase and amplitude as
(a) 100, zero, 5 respectively (b) 50, zero, 5 respectively
(c) 200, zero, 5 respectively (d) 50, π, 5 respectively

20. Consider a pulse propagating in negative and direction with wave speed V. Shape of the displacement pulse at $t = t_0$ is given by $y = \frac{b^2}{a^2 + (x - x_0)^2}$. What is the shape of the pulse at a later time t.
(a) $y = \frac{b^2}{a^2 + (x - x_0)^2 + v(t - t_0)^2}$
(b) $y = \frac{b^2}{a^2 + [x - x_0 + v(t - t_0)]^2}$
(c) $y = \frac{b^2}{a^2 + [x + v(t - t_0)]^2}$
(d) $y = \frac{b^2}{a^2 + [x + vt - x_0)]^2}$

21. In question 17, particle at origin will be displaced to the maximum at a time.
(a) $\frac{x_0}{v}$ (b) $\frac{x_0 + vt_0}{v}$
(c) $\frac{x_0 - vt_0}{v}$ (d) none of these

22. In question 17, maximum displacement of any point will be
(a) b/a (b) b^2/a^2 (c) b^2 (d) none

Passage (E)

β-Particle: These are high energy electrons emitted by certain types of radioactive nuclei such as potassium-40. The beta particles emitted are a form of ionizing radiation also known as beta rays. The production of beta particles is termed beta decay. They are designated by the Greek letter beta (β). There are two forms of beta decay, β^- and β^+, which respectively give rise to the electron and the positron.

β^- Decay (electron):
Unstable atomic nuclei with an excess of neutrons may undergo b– decay, where a neutron is converted into a proton, an electron and an electron-type antineutrino (the antiparticle of the neutrino):

$$n \rightarrow p + e^- + v_e$$

The electron and the antineutrino are emitted from the nucleus.

β^+ Decay (positron):
Unstable nuclei that are deficient in neutrons may undergo b+ decay, where a proton is converted into a neutron. The proton consists of two up quarks and a down quark, one of the proton's up quarks decays to a down quark, doing so, it will emit a W particle, which is unstable and decays further into a positron, and an electron neutrino:

$$p \rightarrow n + e + v_e$$

The positron and the neutrino are emitted from the nucleus

$$p\,(\text{uud}) \rightarrow n\,(\text{udd}) + W^+ \rightarrow e^+ + v_e$$

The neutrino and conservation of energy:
Due to the presence of the neutrino, the atom and the beta particle do not usually recoil in opposite directions. This observation led Wolfgang Pauli to postulate the existence of neutrinos in order to prevent violation of conservation of energy and momentum laws. Beta decay is mediated by the weak nuclear force. Beta particles may be stopped by a few mil (1/1000 in.) of aluminium. A beta particle's flight is ten times farther than an alpha particle, although it ionizes a tenth less than an alpha particle.

23. Choose the wrong statement
(a) β particles are charged particles with mass
(b) β particles can have both positive and negative charge
(c) energy of β-particles are equal to these of neutrons
(d) protons and neutrons both are unstable particles

24. A particle x is designated as x (uud) then it is a
(a) neutron (b) neutrino
(c) proton (d) none of these

25. During decay of W^+ which does not remain conserved
(a) mass (b) total energy
(c) total charge (d) linier momentum

26. For a nucleus which is neither deficient in protons nor in neutrons will not undergo any evident beta decay. But via weak nuclear forces neutrons get converted into protons and protons into neutrons. This implies that
(a) e^- and e^+ must annihilate each other
(b) $\overline{v}_e$ and v_e must annihilate each other
(c) if e^- and e^+ annihilation if emits energy then $\overline{v}_e$ and v_e annihilation must absorb energy
(d) options *a* and *b* are correct

Passage (F)

A travelling harmonic wave is a disturbance in any physical quantity of the form $f(x, t) = f_{max} \cos(kx - wt + \phi)$ or $f_{max} \sin(kx - wt + \phi)$. The quantity w is the angular frequency or the wave, which we have just encountered in harmonic oscillators. The quantity k is called the wave number.

In one sense a travelling harmonic wave is just a string of harmonic oscillators with position dependent phase. You can show this easily by writing $\cos[k(x_0 + x) - wt + \phi] = \cos[kx_0 - wt + \phi(x)]$, where $\phi(x) = \phi + kx$. So the 'oscillator' at $x_0 + x$ is the same as the 'oscillator' at x_0, but with kx added to its phase. The rate of change of phase of the oscillators with distance along the x-axis is just $(d/dx)\,\phi(x) = k$. As with a harmonic oscillator, the temporal period of the oscillator at a fixed point in space is given by $2\pi/\omega$. But the wave is also periodic in space at fixed time with a period, called the wavelength, of $(2\pi)/k$. The relation between the maximum values of the function and its time derivatives (for fixed x) are the same as for a harmonic oscillator, for fixed x, $(df/dt)_{max} = wf_{max}$ and $(d_2f/dt^2)_{max} = w\,(df/dt)\text{max} = w^2 f_{max}$. It is important to realize that what is travelling (propagating) in a travelling wave is the value of the quantity being represented by the wave. As time progresses, every value of the function moves down the x-axis with constant velocity. The entire wave movew as a unit. If every value travels a distance dx in an amount of time dt, we must have $f(x + dx, t + dt) = f(x, t)$, or cos $[k(x + dx) - w(t + dt) + \phi]$, for all values of t and x. The only way this can be true is if the arguments of the cos functions at the two times and places are the same: $k(x + dx) - w(t + dt) + \phi = kx - wt + \phi$. Collecting terms we have that the speed with which any value of the wave moves along the x-axis is given by $dx/dt = w/k = v_p$, where v_p is called the phase velocity or velocity of propagation of the wave. This result for the phase velocity of a travelling wave is purely kinematical, a property which any physical quantity undergoing 'harmonic travelling wave motion' must have. The value of the phase velocity of a real, physical wave depends on the Physics of the process. We have so far dealt with harmonic waves in the one dimension, but it will be useful to generalize this to three dimensions by defining a vector k. If we write the position vector as $r = r_{par} + r_{perp}$, where r_{par} is the component of r parallel to k, and r_{perp} is the component of r perpendicular to k, we see that $k.r = kr_{per}$ has the same value at any point on the plane perpendicular to k which contains the point at r. We will write the wave as $f = f_{max}\cos(k.r. - wt + \phi)$ and not that the argument and therefore, the value of the function (for fixed t) is the same as every point on the plane. Such a wave is therefore called a plane, travelling, harmonic wave propagating in the direction of k. In the same way, it will also be useful to define spherical and cylindrical waves in three dimensions, although the mathematics is somewhat more complicated. The meaning, however, is similar. In a cylindrical wave, all points on the surface of a cylinder at a fixed time have the same value of the wave. In a spherical wave, all points on the surface of a sphere at a fixed time have the same value of the wave.

27. Two point separated by a distance x along x-axis while a plane wave is propagating along y-axis will have phase different of
(a) $\frac{2\pi}{k}\,x$ (b) $\frac{2\pi}{\lambda}$
(c) kx (d) zero

28. Spatial period of a wave is called
(a) wave number (b) wave length
(c) time period (d) none of these

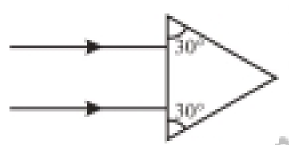
29. Ratio of maximum particle speed and pahse velocity will be .... if maximum displacement be 5 cm, and wave be defined in particle velocity $V = 5 \sin (5x - wt)$. Where all the quantities in this equation are in S.I units and w is unknown which is to be determined from other data.
(a) 1 : 4 (b) 4 : 1 (c) 5 : 1 (d) 1 : 5

30. A plane wave is travelling in space such that each and every point on the plane $x + y + z = \sqrt{3}$ has same phase. Displacement amplitude of the wave is 2 cm, wavelength of the ϕ wave is 2 cm, wave length of the ϕ wave is 6 m while its angular frequency ω is 100π. At $t = 0$, displacement the point at the origin is 2 cm. Then what is the displacement of the particle at $P(0, 3\sqrt{3}, 0)$ at time $t = 5$ s is
(a) 1 cm (b) $\sqrt{3}$ cm (c) zero (d) 1/2 cm

Question No: 31 to 60 are multiple choice questions. Choose the correct alternative/s in each

31. The amplitude of a wave disturbance propagating in the positive x-direction is given by $y = \frac{1}{1 + x^2}$ at time $t = 0$ and by $y = \frac{1}{1 + (x-1)^2}$ at $t = 2$ seconds, where x and y are in meters. The shape of the wave disturbance doesn't change during the propagation. The velocity of the wave, in m/s.
(a) 1.0 (b) 0.5 (c) 0.8 (d) 1.5

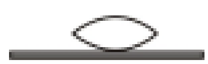
32. Two parallel light rays are incident at one surface of a prism of refractive index 1.5 (see figure). What is the angle between the rays as they emerge ?



(a) 19° (b) 30° (c) 37° (d) 45°

33. Two pipes (both closed at one end), when set into vibrations produce 6 beats per second. l_1 and l_2 denote there lengths respectively. On changing the length of one of them it was seen that the beat freqeuency increases. If $l_1 > l_2$ initially then it may be said that
(a) l_1 was increased (b) l_2 was increased
(c) l_1 was decreased (d) none of these

34. The power convex lens placed in contact with a plane mirror as shown in the figure is P. If the space between the mirror and the lens is filled with water, the power of the new combination now formed will be

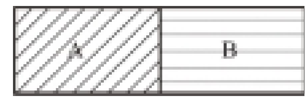


(a) more than P (b) less than P
(c) P (d) may be any of the above

35. White light is used to illuminate the two slits in Young's double slit experiment. The separation between the slits is b and the screen is at a distance D from the slits. At a point on the screen directly in front of one of the slits, the wavelength(s) which will exhibit maxima is (are)
(a) $d^2/2D$ (b) d^2/D
(c) $2d^2/D$ (d) none of these

36. A tuning fork whose frequency is given by a manufacture as 480 Hz. is being tested with an accurate oscillator. It is found that the fork produces a beat frequency of 4 Hz when the oscillator reads 480 Hz, but produces a beat of 6 Hz when the oscillator reads 478 Hz. When the oscillator reads 482 Hz, the beat frequency will be
(a) 2 Hz (b) 0 Hz (c) 6 Hz (d) 8 Hz

37. A wall has two layers A and B, each made of different materials. The thickness of both the layers is the same. The thermal conductivity of A, $K_A = 3 K_B$. The temperature across the walls is 20° C in thermal equilibrium



(a) the temperature difference across A = 15° C
(b) rate of heat transfer across A is more than across B
(c) rate of heat transfer across both is same
(d) none of these

38. The energy radiated per second by a spherical black body will be doubled if its
(a) radius is increased by nearly 41.5%
(b) radius is doubled
(c) temperature (T) is increased by nearly 41.5%
(d) none of these

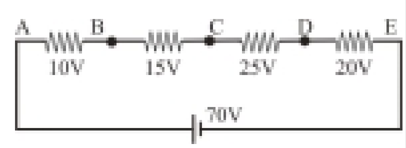
39. Steam at 100°C is passed into 1.1 kg of water contained in a colorimeter of water equivalent 0.02 kg at 15° C till the temperature of the calorimeter and its contents rises to 80° C. The mass of the steam condensed in kilogram is
(a) 0.130 (b) 0.065 (c) 0.0260 (d) 0.135

40. In an adiabatic compression process performed on a 2 mole of monoatomic gas, the percentage change in volume is 0.1%. The percentage change in temperature for this process is
(a) 0.66 (b) 0.44 (c) 0.88 (d) 0.22

41. The meter is defined as 1, 650, 763.73 wavelengths of the orange light emitted by a light source, containing Krypton-86 atoms. The corresponding photon energy of this radiation
(a) 1.80 eV (b) 2.5 eV (c) 1.99 eV (d) none

42. A photocell is operable with visible light. There are four different metallic surfaces with the following work function metal given in the options. Which of the metal can do this whose work functions are
(a) 4.2 eV (b) 4.5 eV (c) 2.5 eV (d) none

43. Which level of the doubly ionized lithium (Li^{+1}) has the same energy as the ground state of hydrogen ?



(a) 1 (b) 2 (c) 3 (d) 4

44. In the circuit shown, if the point B is grounded, the potential at the point D will be .... volt
(a) – 44 V (b) – 24 V (c) – 40 V (d) + 20 V

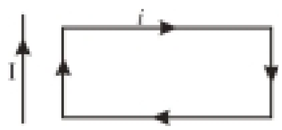
45. A wheel with 10 metallic spokes each 0.5 m long is rotated at a speed of 120 rev/min in a plane normal to the earth's magnetic field. If the magnitude of the field at the place is 0.4×10^{-4} T, the induced emf between the axle and the rim of the wheel is
(a) 6.28×10^{-5} V (b) 4.56×10^{-5} V
(c) $\pi \times 10^{-5}$ V (d) $\pi/2 \times 10^{-3}$ V s

46. A d.c. voltage of 10 V is swithched on to a coil whose inductance is L = 0.5 H and which is in series with a resistance of 10Ω. The voltage across the inductor is proportional to
(a) e^{-5t} (b) e^{-20t} (c) e^{-t} (d) e^{-15t}

47. A charge Q is placed at one of the corners of a cube. The electric flux through the shaded face of the cube is
(a) $\frac{Q}{24\,\varepsilon_0}$ (b) $\frac{Q}{6\,\varepsilon_0}$
(c) $\frac{Q}{48\,\varepsilon_0}$ (d) $\frac{Q}{12\,\varepsilon_0}$

48. The mean free path of a molecule of diameter 'd' is given by $\lambda = \frac{1}{\lambda\sqrt{2}d^2 n_0}$, where n_0 is the number of molecules per unit volume. Then
(a) mean free path will increase on increasing the temperature
(b) mean free path decreases on increase of temperature
(c) mean free path doesn't depend in pressure and temperature
(d) none of these

49. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If a steady current I is established in the wire as shown in the figure, the loop will



(a) rotate about an axis parallel to the wire
(b) move away from the wire
(c) move towards the wire (d) remain stationary

50. Two bulbs of equal wattage, one having carbon filament and other having a tungsten filement, are connected in series to the mains. After some times
(a) both bulbs glow equally
(b) carbon filament bulb glows more
(c) tungsten filament bulb glows more
(d) none of these

51. A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. The magnitude of the angular momentum of the projectile about the point of projection when the particle is at its maximum height h is
(a) zero (b) $mV^3/(4\sqrt{2}g)$
(c) $\frac{mV^3}{\sqrt{2g}}$ (d) $mV\sqrt{2}\,gh^3$

52. A resistor length is in the shape of a truncated right circular cone. The end radii are r_1 and r_2 $(r_2 > r_1)$ and the length is l. If the taper is small, then the resistance between the plane faces of this resistor is
(a) $\frac{Kl}{\pi r_1^2}$ (b) $\frac{Kl}{\pi r_2^2}$
(c) $\frac{Kl}{\pi\, r_1 r_2}$ (d) $\frac{K\pi\, r_1 r_2}{l}$

53. A stone of mass m, tried to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then the tension in the string is given by $T = Ar^n$, where A is constant, r is the instantaneous radius of the circle, then the value of n is
(a) 2 (b) – 1 (c) – 3 (d) – 4

54. A cylinder of mass M and radius R is resting in a horizontal platform (which is parallel to the x-y plane) with its axis fixed along the y-axis and free to rotate about the axis. The platform is given a motion in the x-direction given by $x = A\cos\omega t$. There is no slipping between the cylinder and the platform. The maximum torque acting on the cylinder during its motion is
(a) 1/2 MRA ω^2 (b) 3/2 MRA ω^2
(c) 5/2 MRA ω^2 (d) MRA ω^2

55. A satellite moves around the earth in a circular orbit of radius r with speed v. If mass of the satellite is m, its total energy is
(a) $1/2\, mv^2$ (b) $-1/2\, mv^2$
(c) $5/2\, mv^2$ (d) none of these

56. A mass suspended from a massless spring stretches it by a distance x. The time period of oscillation of the spring is proportional to
(a) $\sqrt{x}$ (b) $1/\sqrt{x}$ (c) x (d) $x^{1/3}$

57. A massive circular loop of radius r oscillates in its own plane about a horizontal axes at a distance x above the centre of the loop. The period of oscillation is minimum when x equals
(a) r (b) $r/2$ (c) $r/3$ (d) zero

58. A uniform rod AB of mass m and length l is at rest on a smooth horizontal surface. An impulse P is applied to the end B. The time taken by the rod to turn through right angle is
(a) $2\pi\frac{ml}{P}$ (b) $2\pi\frac{P}{ml}$
(c) $\frac{\pi}{12}\,\frac{ml}{P}$ (d) $\frac{\pi P}{ml}$

59. The maximum power delivered by a force in S.H.M ($x = A\sin wt$) is at
(a) $x = A/2$ (b) $x = A/\sqrt{2}$
(c) $x = 3/4\,A$ (d) $x = 0$

60. Two equal negative charges $-q$ are fixed at the points $(0, a)$ and $(0, -a)$ on the y-axis. A positive charge Q is released from rest at the point $(2a, 0)$ on the x-axis. The charge Q will
(a) execute SHM about the origin
(b) move to the origin and remain at rest
(c) move to infinity
(d) oscillate out not simple harmonically