NEET Physics Sample Paper 05

A) Subject: Physics
B) Total Questions: 45 Questions (All Compulsory)
C) Marking Scheme & Rules:

- Correct Answer: +4 marks
- Incorrect Answer: -1 mark (Negative marking)
- Unattempted Question: 0 marks
- Multiple Answers: Treated as incorrect, attracting -1 mark

Q1. The dimensional formula for the product of permittivity (ϵ_0) and permeability (μ_0) in free space, ($\mu_0\epsilon_0$), is:

A. $[L^2T^{-2}]$

B. $[L^{-2}T^2]$

C. $[L^{-2}T^2]$

D. $[LT^{-1}]$

Q2. A person traveling on a straight line moves with a uniform velocity v_1 for some time and with uniform velocity v_2 for the next equal interval of time. The average velocity v is given by:

A. $v = \sqrt{v_1 v_2}$

B. $v = \frac{2v_1v_2}{v_1+v_2}$

C. $v = \frac{v_1+v_2}{2}$

D. $v = \frac{1}{v_1} + \frac{1}{v_2}$

Q3. The speed of a projectile at its maximum height is half of its initial speed u. The horizontal range of the projectile is:

A. u^2/g

B. $\sqrt{3}u^2/2g$

C. $u^2/2g$

D. $\sqrt{3}u^2/g$

Q4. A block of mass m is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally so that the block does not slip on the wedge. The magnitude of the horizontal acceleration is:

A. $g \sin\theta$

B. $g \cos \theta$

C. $g \tan \theta$

D. $g \cot \theta$

Q5. A pump on the ground floor of a building can pump up water to fill a tank with a volume of 30 m^3 in 15 minutes. If the tank is 40 m above the ground, and the efficiency of the pump is 30%, how much electric power is consumed by the pump? ($g = 10$ m/s^2)

A. 13.3 kW

B. 26.6 kW

C. 44.4 kW

D. 30 kW

Q6. A body of mass m_1 moving with a velocity u undergoes a head-on elastic collision with another body of mass m_2 at rest. If $m_1 \gg m_2$, the velocity of the second body after the collision is approximately:

A. u

B. $2u$

C. $u/2$

D. Zero

Q7. A circular disc of mass M and radius R is rotating about its central axis with angular velocity ω. If a person stands on the edge of the disc, the moment of inertia of the system will:

A. Decrease

B. Increase

C. Remain same

D. Become zero

Q8. If the distance between the Earth and the Sun were doubled, the duration of the year would be:

A. 2 years

B. 4 years

C. $2\sqrt{2}$ years

D. 8 years

Q9. A steel wire of length 2 m and cross-sectional area 0.5 mm^2 is stretched by a force of 100 N. If Young's modulus for steel is 2×10^{11} Pa, the extension produced is:

A. 1 mm

B. 2 mm

C. 0.5 mm

D. 4 mm

Q10. According to Bernoulli's principle, in a horizontal pipe carrying a fluid, as the velocity of the fluid increases:

A. The pressure increases.

B. The pressure decreases.

C. The potential energy increases.

D. The density decreases.

Q11. Which of the following laws states that "no process is possible whose sole result is the transfer of heat from a colder object to a hotter object"?

A. First law of thermodynamics

B. Second law of thermodynamics (Clausius statement)

C. Zeroth law of thermodynamics

D. Third law of thermodynamics

Q12. The temperature of an ideal gas is increased from 27°C to 127°C. The ratio of final RMS speed to initial RMS speed is:

A. 4/3

B. 3/4

C. $\sqrt{4/3}$

D. $\sqrt{3/4}$

Q13. A particle executing SHM has a maximum velocity v_m and maximum acceleration a_m. The amplitude of oscillation is:

A. a_m/v_m

B. v_m/a_m

C. v_m^2/a_m

D. a_m^2/v_m

Q14. In a stationary wave, the distance between a node and the adjacent antinode is:

A. λ

B. $\lambda/2$

C. $\lambda/4$

D. 2λ

Q15. The number of electrons in one Coulomb of negative charge is:

A. 1.6×10^{-19}

B. 6.25×10^{18}

C. 6.25×10^{20}

D. 9×10^{9}

Q16. The electric potential at a distance r from an electric dipole on its axis is proportional to:

A. $1/r$

B. $1/r^2$

C. $1/r^3$

D. r^2

Q17. A capacitor of 10 mF is charged to 100 V. The energy stored in the capacitor is:

A. 1 J

B. 0.1 J

C. 0.05 J

D. 0.01 J

Q18. The resistance of a wire is R. If it is melted and recast to half its original length, the new resistance will be:

A. $2R$

B. $R/2$

C. $R/4$

D. $4R$

Q19. In a potentiometer experiment, the balancing length is 250 cm for a cell. When a shunt of 5 Ω is connected across the cell, the balancing length becomes 200 cm. The internal resistance of the cell is:

A. 1.0 Ω

B. 1.25 Ω

C. 1.5 Ω

D. 2.0 Ω

Q20. A charge q moves with velocity v in a magnetic field B. The force experienced is maximum when the angle between v and B is:

A. 0°

B. 45°

C. 90°

D. 180°

Q21. Susceptibility is positive and large for:

A. Diamagnetic substances

B. Paramagnetic substances

C. Ferromagnetic substances

D. Non-magnetic substances

Q22. A square loop of side 10 cm and resistance 0.5 Ω is placed vertically in the east-west plane. A uniform magnetic field of 0.1 T is set up across the plane in the north-east direction. The magnetic field is decreased to zero in 0.7 s at a steady rate. The magnitude of induced EMF is:

A. 1.0 mV

B. 0.5 mV

C. 2.0 mV

D. Zero

Q23. In a series LCR circuit, at resonance, the impedance of the circuit is:

A. Maximum

B. Minimum (equal to R)

C. Zero

D. Infinite

Q24. Which electromagnetic wave is used in "night vision" goggles?

A. Microwaves

B. Infrared waves

C. Ultraviolet waves

D. X-rays

Q25. A point object is placed at a distance of 30 cm from a convex lens of focal length 20 cm. The image will be formed at a distance of:

A. 30 cm

B. 60 cm

C. 20 cm

D. 10 cm

Q26. A particle moves such that its position vector is given by $\vec{r} = \cos(\omega t)\hat{i} + \sin(\omega t)\hat{j}$. The velocity of the particle is:

A. Parallel to the position vector

B. Perpendicular to the position vector

C. Directed towards the origin

D. Directed away from the origin

Q27. A ball of mass 0.15 kg is dropped from a height of 10 m, strikes the ground and rebounds to the same height. The magnitude of impulse imparted to the ball is ($g = 10$ m/s^2):

A. 0 N s

B. 2.1 N s

C. 1.4 N s

D. 4.2 N s

Q28. A engine develops 10 kW power. How much time will it take to lift a mass of 200 kg to a height of 40 m? ($g = 10$ m/s^2):

A. 4 s

B. 5 s

C. 8 s

D. 10 s

Q29. Two bodies of masses m and $4m$ are moving with equal kinetic energies. The ratio of their linear momenta is:

A. 1 : 4

B. 1 : 2

C. 4 : 1

D. 1 : 1

Q30. A constant torque of 31.4 N m is exerted on a pivoted wheel. If the angular acceleration of the wheel is 4π rad/s^2, then the moment of inertia of the wheel is:

A. 2.5 kg m^2

B. 2.5 kg m^2

C. 5.0 kg m^2

D. 10 kg m^2

Q31. The ratio of escape velocity at Earth (v_e) to the escape velocity at a planet (v_p) whose radius and mean density are twice as that of Earth is:

A. 1 : 2

B. 1 : $2\sqrt{2}$

C. 1 : 4

D. 1 : $\sqrt{2}$

Q32. A spherical drop of mercury of radius 2 mm is broken into 8 droplets of equal size. The work done is (Surface tension of mercury = 0.465 N/m):

A. 1.15×10^{-5} J

B. 2.3×10^{-5} J

C. 4.6×10^{-5} J

D. 3.1×10^{-5} J

Q33. A Carnot engine has the same efficiency when working between (i) 100 K and 500 K and (ii) T K and 600 K. The value of T is:

A. 100 K

B. 120 K

C. 150 K

D. 200 K

Q34. The pressure of an ideal gas is written as $P = \frac{2}{3}E$, where E stands for:

A. Average kinetic energy

B. Kinetic energy per unit volume

C. Total energy

D. Potential energy per unit volume

Q35. A particle is executing SHM with an amplitude A. At what displacement from the mean position is its energy half kinetic and half potential?

A. $A/2$

B. $A/\sqrt{2}$

C. $A/4$

D. $\sqrt{3}A/2$

Q36. A train blowing its whistle moves with constant speed on a straight track towards an observer at rest. The observer hears a frequency f_1. If the train moves away from the observer, the frequency heard is f_2. If v is the speed of sound and v_s is the speed of the train, then f_1/f_2 is:

A. $(v + v_s)/(v - v_s)$

B. $(v + v_s)/(v - v_s)$

C. $(v - v_s)/(v + v_s)$

D. v/v_s

Q37. Two point charges $+9e$ and $+e$ are kept at a distance of 16 cm. At what distance from $+9e$ should a third charge q be placed so that the system is in equilibrium?

A. 4 cm

B. 8 cm

C. 12 cm

D. 6 cm

Q38. Six capacitors each of capacitance C are connected as shown in the figure and then connected to a battery. The equivalent capacitance between A and B is:

A. $6C$

B. $3C$

C. $1.5C$

D. $C/3$

Q39. A copper wire of length 1 m and radius 1 mm is joined in series with an iron wire of length 2 m and radius 3 mm and a current is passed through them. The ratio of the current densities in the copper and iron wires is:

A. 2 : 3

B. 3 : 2

C. 1 : 1

D. 9 : 1

Q40. A proton and an alpha particle move in circular orbits in a uniform magnetic field. Their speeds are in the ratio 9 : 4. The ratio of the radii of their circular orbits (r_p/r_α) is:

A. 1 : 1

B. 9 : 8

C. 8 : 9

D. 4 : 9

Q41. In an AC circuit, an inductance L and a resistance R are connected in series with an AC source. The phase difference between voltage and current is:

A. $\tan^{-1}(\omega L/R)$

B. $\sin^{-1}(\omega L/R)$

C. $\cos^{-1}(\omega L/R)$

D. Zero

Q42. Two slits in Young's experiment have widths in the ratio 1 : 16. The ratio of the maximum to minimum intensity in the interference pattern is:

A. 4 : 1

B. 9 : 4

C. 25 : 9

D. 16 : 1

Q43. The stopping potential for photoelectrons from a surface illuminated by light of frequency v is V_0. If the frequency is doubled, the stopping potential will be:

A. $2V_0$

B. More than $2V_0$

C. Less than $2V_0$

D. V_0

Q44. The ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series of the hydrogen spectrum is:

A. $27 : 5$

B. $5 : 27$

C. $4 : 9$

D. $1 : 4$

Q45. The following truth table represents which logic gate?:

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

A. AND

B. OR

C. NAND

D. NOR

Solutions

1. **(C)** In electromagnetism, the speed of light in vacuum is defined by the relation $c = 1/\sqrt{\mu_0\epsilon_0}$. By squaring both sides and rearranging, we get the product $(\mu_0\epsilon_0) = 1/c^2$. Since the dimensions of speed c are $[LT^{-1}]$, the dimensions of $1/c^2$ become $[L^{-2}T^2]$.

2. **(C)** Average velocity is defined as the total displacement divided by the total time taken. For two equal time intervals t, the displacements are $d_1 = v_1t$ and $d_2 = v_2t$. The total displacement is $(v_1 + v_2)t$ and total time is $2t$. Dividing them gives $v_{avg} = (v_1 + v_2)/2$.

3. **(B)** At the maximum height, the vertical component of velocity is zero, and the speed is simply the horizontal component: $v = u\cos\theta$. Given $u\cos\theta = u/2$, we find $\cos\theta = 1/2$, so $\theta = 60°$. The horizontal range R is calculated as $[u^2 \sin(2\times 60°)]/g = [u^2 \sin 120°]/g = \sqrt{3}u^2/2g$.

4. **(C)** To prevent the block from slipping, the pseudo force ma acting horizontally must have a component along the incline that balances the component of weight. Equating the forces along the incline: $ma\cos\theta = mg\sin\theta$. This simplifies to $a = g(\sin\theta/\cos\theta) = g\tan\theta$.

5. **(C)** Mass of water m = volume × density = $30 \times 1000 = 3 \times 10^4$ kg. Useful work done $= mgh = 30000 \times 10 \times 40 = 1.2 \times 10^7$ J. Power output = Work/Time = $1.2 \times 10^7/900$ s $\approx 13,333$ W. Given 30% efficiency, the electric power consumed is $13,333/0.3 \approx 44,444$ W or 44.4 kW.

6. **(B)** In a head-on elastic collision, the final velocity of the second body is $v_2 = [2m_1u_1/(m_1+m_2)] + [u_2(m_2-m_1)/(m_1+m_2)]$. Since $u_2 = 0$ and $m_1 \gg m_2$, the expression $2m_1/(m_1+m_2)$ effectively becomes $2m_1/m_1 = 2$. Thus, $v_2 \approx 2u$.

7. **(B)** Moment of inertia is given by $I = \Sigma m_i r_i^2$, which depends on the distribution of mass relative to the axis of rotation. When a person stands on the edge of the disc, mass is added at the maximum possible distance R from the axis, which increases the total moment of inertia of the system.

8. **(C)** Kepler's Third Law states that $T^2 \propto R^3$. If the distance R is doubled, the new time period T' satisfies $(T'/T)^2 = (2R/R)^3 = 8$. Taking the square root of both sides, we find $T' = \sqrt{8}T = 2\sqrt{2}$ years.

9. **(B)** Using the formula for Young's modulus $Y = (F/A)/(\Delta L/L)$, we rearrange for extension: $\Delta L = FL/AY$. Substituting the values: $(100 \times 2)/(0.5 \times 10^{-6} \times 2 \times 10^{11}) = 200/10^5 = 0.002$ m, which is equal to 2 mm.

10. **(B)** Bernoulli's equation for horizontal flow is $P + \frac{1}{2}\rho v^2 =$ constant. This indicates that in a fluid system, pressure and velocity are inversely related; as the kinetic energy (velocity) of the fluid increases, the static pressure must decrease to conserve total energy.

11. **(B)** The Clausius statement of the Second Law of Thermodynamics explicitly forbids the spontaneous transfer of heat from a cold reservoir to a hot reservoir. This principle explains why work must be performed by a refrigerator or air conditioner to move heat against its natural gradient.

12. **(C)** The RMS speed of gas molecules is $v_{rms} = \sqrt{3RT/M}$, implying $v_{rms} \propto \sqrt{T}$. Converting temperatures to Kelvin: $T_1 = 300$K and $T_2 = 400$K. The ratio is $\sqrt{T_2/T_1} = \sqrt{400/300} = \sqrt{4/3}$.

13. **(C)** In Simple Harmonic Motion, $v_m = \omega A$ and $a_m = \omega^2 A$. By squaring the velocity expression ($v_m^2 = \omega^2 A^2$) and dividing it by the acceleration expression ($a_m = \omega^2 A$), the ω^2 terms cancel out, leaving $v_m^2/a_m = A$.

14. **(B)** In a stationary wave, the distance between two consecutive nodes or two consecutive antinodes is $\lambda/2$. Since an antinode is located exactly midway between two nodes, the distance from a node to the very next antinode is half of that distance, which is $\lambda/4$.

15. **(B)** Quantization of charge is given by $Q = ne$. To find the number of electrons in 1 C, we use $n = Q/e = 1/(1.6 \times 10^{-19}$ C). This calculation results in 6.25×10^{18} electrons, which is a standard value used to describe the magnitude of one Coulomb.

16. **(B)** For a single point charge, the potential decreases as $1/r$. However, an electric dipole consists of two equal and opposite charges. On the axis, their potentials partially cancel out, leading to a faster decay rate where the net potential V is proportional to $1/r^2$.

17. **(C)** The electrostatic energy stored in a capacitor is $U = \frac{1}{2}CV^2$. Substituting the given values: $0.5 \times (10 \times 10^{-6}\text{ F}) \times (100\text{ V})^2 = 0.5 \times 10^{-5} \times 10000 = 0.05$ J.

18. **(C)** When a wire is recast, its volume $V = AL$ remains constant. If the length L is halved ($L' = L/2$), the cross-sectional area A must double ($A' = 2A$). Since resistance $R = \rho L/A$, the new resistance $R' = \rho(L/2)/(2A) = \frac{1}{4}(\rho L/A) = R/4$.

19. **(B)** The internal resistance r is calculated using the potentiometer formula $r = R(l_1/l_2 - 1)$. Using the balancing lengths $l_1 = 250$ cm (open circuit) and $l_2 = 200$ cm (closed with 5 Ω shunt): $r = 5(250/200 - 1) = 5(1.25 - 1) = 1.25\ \Omega$.

20. **(C)** The magnetic Lorentz force is $F = qvB\sin\theta$. The force reaches its maximum magnitude when $\sin\theta$ is at its maximum value of 1. This occurs when the angle θ between the velocity vector and the magnetic field vector is 90°.

21. **(C)** Magnetic susceptibility (χ) measures how easily a substance is magnetized. Diamagnetic materials have small negative χ, paramagnetic materials have small positive χ, but ferromagnetic materials have very large positive χ, allowing them to retain strong magnetization.

22. **(A)** Initial flux $\phi_1 = BA\cos\theta = 0.1 \times (0.1^2) \times \cos 45° = 0.001 \times 0.707$ Wb. Final flux $\phi_2 = 0$. Induced EMF $e = |\Delta\phi/\Delta t| = (0.000707 - 0)/0.7\text{ s} \approx 0.001\text{ V} = 1.0$ mV.

23. **(B)** At resonance, the inductive reactance X_L and capacitive reactance X_C are equal and cancel each other out in the impedance formula $Z = \sqrt{R^2 + (X_L - X_C)^2}$. This leaves $Z = R$, which is the minimum possible impedance for the circuit.

24. **(B)** Objects at room temperature or body temperature emit thermal radiation primarily in the infrared region of the spectrum. Night vision goggles detect this infrared radiation (heat signatures) and convert it into visible images, allowing for vision in total darkness.

25. **(B)** Using the lens formula $1/v - 1/u = 1/f$, where $u = -30$ cm and $f = +20$ cm: $1/v - 1/(-30) = 1/20 \Rightarrow 1/v = 1/20 - 1/30$. Solving for common denominator: $(3 - 2)/60 = 1/60$. Thus, $v = 60$ cm.

26. **(B)** The position vector is $\vec{r} = \cos(\omega t)\hat{i} + \sin(\omega t)\hat{j}$. By differentiating with respect to time, the velocity vector is found to be $\vec{v} = -\omega \sin(\omega t)\hat{i} + \omega \cos(\omega t)\hat{j}$. The dot product $\vec{r} \cdot \vec{v}$ results in zero, which mathematically confirms that the velocity vector is always perpendicular to the position vector in this uniform circular motion.

27. **(D)** The velocity just before impact is $v = \sqrt{2gh} = \sqrt{2 \times 10 \times 10} \approx 14.14$ m/s. Since it rebounds to the same height, the upward velocity is also 14.14 m/s. The change in momentum is $m(v_{final} - v_{initial}) = 0.15 \times (14.14 - (-14.14)) = 0.15 \times 28.28 \approx 4.24$ N s. This represents the total impulse imparted by the ground.

28. **(C)** Power is the rate of doing work, defined as $P = W/t$. The work required to lift the mass is the change in its potential energy, $mgh = 200 \text{ kg} \times 10 \text{ m/s}^2 \times 40 \text{ m} = 80,000$ J. Rearranging the power formula gives $t = W/P = 80,000/10,000 \text{ W} = 8$ seconds for the engine to complete the task.

29. **(B)** The relationship between momentum p and kinetic energy K is $p = \sqrt{2mK}$. Since both bodies have the same kinetic energy, the ratio of their momenta p_1/p_2 is equal to the square root of the ratio of their masses $\sqrt{m/4m}$, which simplifies to $1/2$. Therefore, the body with four times the mass has twice the momentum.

30. **(B)** According to the rotational analogue of Newton's Second Law, torque is the product of the moment of inertia and angular acceleration ($\tau = I\alpha$). Rearranging for moment of inertia, $I = \tau/\alpha = 31.4/(4 \times 3.14) = 31.4/12.56 = 2.5$ kg m^2. This value represents the rotational inertia of the wheel about its pivot.

31. **(B)** Escape velocity is proportional to $R\sqrt{\rho}$. For a planet with radius $2R$ and density 2ρ, the escape velocity v_p is proportional to $2R\sqrt{2\rho} = 2\sqrt{2}(R\sqrt{\rho})$. Thus, $v_p = 2\sqrt{2}v_e$. The ratio v_e/v_p is $1 : 2\sqrt{2}$, indicating that the stronger gravitational pull of the larger, denser planet requires a much higher escape speed.

32. **(B)** When one drop of radius R breaks into 8 droplets of radius r, volume conservation $(4/3)\pi R^3 = 8 \times (4/3)\pi r^3$ implies $r = R/2 = 1$ mm. The work done is $T \times \Delta A = T(8 \times 4\pi r^2 - 4\pi R^2) = T \times 4\pi R^2$. Substituting $T = 0.465$ and $R = 2 \times 10^{-3}$, we get $0.465 \times 4\pi \times 4 \times 10^{-6} \approx 2.3 \times 10^{-5}$ J.

33. **(B)** The efficiency of a Carnot engine is $\eta = 1 - T_{sink}/T_{source}$. For the first engine, $\eta = 1 - 100/500 = 0.8$. For the second engine to have the same efficiency, $1 - T/600 = 0.8$. This means $T/600 = 0.2$, which leads to $T = 120$ K as the required sink temperature for the second engine.

34. **(B)** From the kinetic theory of gases, the pressure exerted by an ideal gas is $P = \frac{1}{3}\rho v^2 = \frac{2}{3}(\frac{1}{2}\rho v^2)$. The term in the parentheses represents the translational kinetic energy of the molecules contained within a unit volume of the gas. Therefore, E specifically denotes the kinetic energy per unit volume.

35. **(B)** The total energy in SHM is $E = \frac{1}{2}kA^2$. If the energy is half potential and half kinetic, then potential energy $U = \frac{1}{2}E$, which means $\frac{1}{2}kx^2 = \frac{1}{4}kA^2$. Solving for x, we find $x^2 = A^2/2$, or $x = A/\sqrt{2}$. At this specific displacement, the energy is perfectly balanced between its two forms.

36. **(B)** According to the Doppler Effect, the frequency heard when the source moves toward the observer is $f_1 = f[v/(v - v_s)]$, and when it moves away, it is $f_2 = f[v/(v + v_s)]$. Taking the ratio f_1/f_2, the source frequency f and speed of sound v cancel out in the numerators, leaving the ratio as $(v + v_s)/(v - v_s)$.

37. **(C)** For the system to be in equilibrium, the third charge must be placed where the net force from the other two is zero. This point x from charge Q_1 is $x = \sqrt{Q_1}d/(\sqrt{Q_1} + \sqrt{Q_2})$. Substituting $Q_1 = 9e, Q_2 = e$, and $d = 16$ cm, we get $x = 3 \times 16/(3 + 1) = 48/4 = 12$ cm from the $+9e$ charge.

38. **(C)** Each branch consists of two capacitors C connected in series, giving each branch an equivalent capacitance of $C/2$. Since there are three such identical branches connected in parallel across the points A and B, the total equivalent capacitance is the sum of the three branches: $C/2 + C/2 + C/2 = 1.5C$.

39. **(D)** In a series circuit, the same current I passes through both wires. Current density J is defined as $I/A = I/(\pi r^2)$, which means J is inversely proportional to the square of the radius. The ratio J_{copper}/J_{iron} is $(r_{iron}/r_{copper})^2 = (3 \text{ mm}/1 \text{ mm})^2 = 9 : 1$, regardless of the lengths of the wires.

40. **(B)** The radius of a circular orbit in a magnetic field is $r = mv/qB$. For a proton (m, q) and an alpha particle $(4m, 2q)$, the ratio r_p/r_α is $(mv_p/q)/(4mv_\alpha/2q) = (v_p/1)/(2v_\alpha)$. Substituting the speed ratio $v_p/v_\alpha = 9/4$, the radius ratio becomes $9/4 \times 1/2 = 9/8$.

41. **(A)** In a series LR circuit, the inductive reactance X_L leads the resistance R by 90 degrees in a phasor diagram. The phase angle ϕ by which the voltage leads the current is determined by the ratio of the reactance to the resistance: $\tan\phi = X_L/R = \omega L/R$, resulting in $\phi = \tan^{-1}(\omega L/R)$.

42. **(C)** The intensity of light is proportional to the slit width $(I \propto w)$. Given $w_1/w_2 = 1/16$, the amplitude ratio $a_1/a_2 = \sqrt{1/16} = 1/4$. The ratio of maximum to minimum intensity is $((a_1+a_2)/(a_1-a_2))^2 = ((1+4)/(1-4))^2 = (5/-3)^2 = 25/9$, providing the contrast for the interference fringes.

43. **(B)** According to Einstein's photoelectric equation, $eV_0 = h\nu - \Phi$. If the frequency is doubled to 2ν, the new stopping potential V' satisfies $eV' = 2h\nu - \Phi = 2(h\nu - \Phi) + \Phi = 2eV_0 + \Phi$. Dividing by e gives $V' = 2V_0 + \Phi/e$, which is clearly more than double the original stopping potential.

44. **(B)** The longest wavelength in Lyman series (transition $n = 2$ to $n = 1$) is $\lambda_L = 4/3R$. The longest wavelength in Balmer series (transition $n = 3$ to $n = 2$) is $\lambda_B = 36/5R$. The ratio $\lambda_L/\lambda_B = (4/3R)/(36/5R) = (4/3) \times (5/36) = 5/27$, which reflects the energy difference between these standard spectral series.

45. **(B)** The truth table shows that the output Y is 1 if either input A is 1, input B is 1, or both are 1. The only case where the output is 0 is when both inputs are 0. This logical operation corresponds exactly to the OR gate, which performs logical addition of its inputs.