Section A

There are 45 questions in this section. Each question is followed by four suggested answers.

AL candidates are required to answer questions 1 to 45. ASL candidates are required to answer questions 1 to 25.

Where necessary, take the acceleration due to gravity to be 10 m s\(^{-2}\) and take the speed of light in air to be \(3 \times 10^8\) m s\(^{-1}\).

1. Two identical bricks \(P\) and \(Q\) are adhered to each other. Each brick is of length 24 cm and they are placed on the edge of a table as shown. \(P\) overhangs the table by 4 cm while \(Q\) overhangs \(P\) by \(x\) cm. What is the maximum value of \(x\) so that the system can still be in equilibrium?

A. 4  
B. 8  
C. 12  
D. 16

2. On a rough incline that makes an angle of 30° to the horizontal, a light spring of force constant 100 N m\(^{-1}\) is fixed at one end \(O\) while a block of mass 1 kg is attached to its other end as shown. The spring is parallel to the incline.

The block can remain at rest when the extension of the spring is 8 cm. Find the magnitude and direction of the frictional forces acting on the block.

A. 3 N down the incline  
B. 3 N up the incline  
C. 8 N down the incline  
D. 8 N up the incline

3. A small ball of mass \(m\) hits the ground with speed \(v\) in a direction making an angle \(\theta\) with the ground. It rebounds with the same speed \(v\) in another direction making the same angle \(\theta\) with the ground. Find the impulse delivered to the ball during collision.

A. \(2mv \sin \theta\)  
B. \(2mv \cos \theta\)  
C. \(mv \sin \theta\)  
D. \(mv \cos \theta\)
Blocks \( P, Q \) and \( R \), connected by light inextensible threads, are placed on a smooth horizontal surface as shown. A constant force \( F \) is applied to \( P \) so that the whole system travels to the right with acceleration. If a lump of plasticine is placed on \( Q \) and it moves together with \( Q \) while the applied force \( F \) remains unchanged, how would the tensions \( T_1 \) and \( T_2 \) in the two threads change?

<table>
<thead>
<tr>
<th>Tension ( T_1 )</th>
<th>Tension ( T_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. decrease</td>
<td>increase</td>
</tr>
<tr>
<td>B. decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>C. increase</td>
<td>increase</td>
</tr>
<tr>
<td>D. increase</td>
<td>decrease</td>
</tr>
</tbody>
</table>

Blocks \( X \) and \( Y \) are initially held stationary on the inclining surfaces \( PQ \) and \( QR \) of a wedge. The wedge rests on a horizontal surface and all contact surfaces are smooth. After releasing the blocks simultaneously, the wedge \( PQR \) remains at rest when the blocks are sliding down the inclining surfaces. If the mass of block \( X \) is 2 kg, find the mass of block \( Y \).

A. \( \sqrt{2} \) kg  
B. 1 kg  
C. 2 kg  
D. \( 2\sqrt{2} \) kg

The figure shows a 2 kg block moving at a speed of 0.5 m \( \text{s}^{-1} \) on a smooth horizontal surface. It collides head-on elastically with an initially stationary block of mass 3 kg which is fitted with a light spring. What is the maximum elastic potential energy stored in the spring during collision?

A. 0.10 J  
B. 0.15 J  
C. 0.25 J  
D. It cannot be found as the force constant of the spring is not known.
A particle is projected horizontally towards a vertical wall 1.5 m away. It hits the wall 1.0 m below the initial horizontal level. At what angle to the vertical does the particle hit the wall?

A. 34°
B. 37°
C. 53°
D. 56°

Two identical light springs are joined in series and in parallel as shown. Identical masses are attached to both spring systems. What is the ratio of the period of the vertical simple harmonic motion of the series spring system to that of the parallel spring system?

A. 2 : 1
B. 1 : 2
C. 4 : 1
D. 1 : 4

In order to check the speed of a camera shutter, the camera was used to photograph the bob of a simple pendulum swinging in front of a horizontal scale. The extreme positions of the bob were at the 450 mm and 550 mm marks on the scale. The photograph showed that the bob moved from the 500 mm mark to the 525 mm mark when the shutter was open.

If the period of the pendulum was 1.5 s, the shutter remained open for approximately

A. 1/2 s
B. 1/4 s
C. 1/8 s
D. 3/8 s

An object performs simple harmonic motion. Which of the following physical quantities is doubled when its amplitude is doubled?

A. period of oscillation
B. maximum momentum
C. maximum potential energy
D. total mechanical energy
11. 

S_1 and S_2 are two loudspeakers connected to a signal generator. The separation between S_1 and S_2 is 0.8 m. A student moves a microphone along a line PP' 8.0 m away from the loudspeakers and parallel to S_1S_2. Loud sound is detected consecutively at P, O and P'. If PP' equals 2.0 m, estimate the wavelength of the sound produced by the loudspeakers.

A. 5 cm  
B. 10 cm  
C. 15 cm  
D. 20 cm

12. Two diffraction gratings P and Q have the same overall size as well as the same slit width, but the slit separation of P is half that of Q. A beam of white light is incident normally on each grating in turn and the spectrum of the light is observed in each case. Which of the following about the observed spectra are correct?

(1) For both gratings, the zero-order image at the centre is white.  
(2) The width of the entire first-order spectrum of P is broader than that of Q.  
(3) The first-order spectrum of P is at the same place as the second-order spectrum of Q.

A. (1) and (2) only  
B. (1) and (3) only  
C. (2) and (3) only  
D. (1), (2) and (3)

13. The figure shows an insulated conductor which carries negative charges. An earthed metal sphere is now brought close to this charged conductor without touching its surface. Which of the following statements is/are correct?

(1) The sphere gains positive charge.  
(2) The charged conductor loses positive charge.  
(3) The electric potential of the charged conductor becomes more negative.

A. (1) only  
B. (1) and (2) only  
C. (1) and (3) only  
D. (2) and (3) only
A point charge +Q is fixed at point A while another point charge -2Q is fixed at point B as shown. $E_A$ and $E_B$ denote the magnitude of the electric field due to the point charge at A and B respectively. For the points on the line passing through A and B, how many of them has/have $E_A = E_B$ and how many has/have zero resultant field? (No need to consider the points at infinity.)

A. There are 3 points with $E_A = E_B$ and the resultant field is zero at 2 of them.
B. There are 2 points with $E_A = E_B$ and the resultant field is zero at both of them.
C. There are 2 points with $E_A = E_B$ and the resultant field is zero at 1 of them.
D. There is 1 point with $E_A = E_B$ and the resultant field is zero at that point.

15.

![Graph of current vs. voltage](image)

The above graph shows the $I$-$V$ relationship of an electric component. Which of the following deductions is/are correct?

(1) When the applied voltage is 0.5 V, the component has infinite resistance.
(2) When the applied voltage exceeds 1 V, the component's resistance is constant.
(3) When the applied voltage exceeds 1 V, the voltage is directly proportional to the current.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

16. A battery has a constant e.m.f. and a fixed internal resistance is connected to a variable resistor of resistance $R$. Which of the following graphs correctly show the variation of the physical quantities $I$, $V$ and $P$ with the resistance $R$?

$I$ = the ammeter reading
$V$ = the voltmeter reading
$P$ = the total power delivered by the battery

(1) $I$ versus $R$
(2) $V$ versus $R$
(3) $P$ versus $R$

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)
17. Which of the following statements about the deflection of a charged particle in a uniform electric field or a uniform magnetic field are correct?

(1) Only magnetic field can deflect the charged particle by more than 90°.
(2) Only electric field can increase the speed of the charged particle.
(3) In either field, the acceleration of the charged particle depends on the magnitude of the charge.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

18. In the figure, \( PQRS \) is a metal plate placed normally to a uniform magnetic field pointing into the paper. At the instant shown, the magnetic field is moving to the right and eddy current is induced in the metal plate. Which of the following diagrams best represents a possible path of the eddy current induced in the plate?

A. 
B. 
C. 
D. 

19. When 240 V a.c. is applied across \( PQ \) of the ideal transformer circuit, the voltages measured across \( RS \) and \( ST \) are 4 V and 8 V respectively. If 6 V a.c. is now applied across \( ST \), what will be the voltages measured across \( PQ \) and \( RS \)? (Both \( PQ \) and \( RS \) are open.)

<table>
<thead>
<tr>
<th>Voltage across ( PQ )</th>
<th>Voltage across ( RS )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 0 V</td>
<td>0 V</td>
</tr>
<tr>
<td>B. 180 V</td>
<td>0 V</td>
</tr>
<tr>
<td>C. 0 V</td>
<td>3 V</td>
</tr>
<tr>
<td>D. 180 V</td>
<td>3 V</td>
</tr>
</tbody>
</table>
20. In the circuit, the capacitor \( C \) contains a charge of 5 \( \mu \text{C} \). The other two capacitors are initially uncharged. After switch \( K \) is closed, what is the p.d. between \( P \) and \( Q \) when steady state is reached?

A. 1 V  
B. 2 V  
C. 3 V  
D. 4 V

21. A battery of e.m.f. 9 V, a capacitor of capacitance 1000 \( \mu \text{F} \) and a motor \( M \) are connected as shown. Initially switch \( S \) is connected to \( X \). When \( S \) is switched to \( Y \), a 20 g mass is raised a vertical distance of 8.1 cm by the motor. Estimate the percentage of the electrical energy in the capacitor being converted to the mechanical energy of the mass by the motor.

A. 40%  
B. 35%  
C. 30%  
D. 25%

22. Which of the following assumptions leads directly to the factor \( \frac{1}{3} \) in deriving the equation \( pV = \frac{1}{3} Nmc^2 \) in kinetic theory of gases?

A. All gas molecules are in random motion.  
B. The gas molecules are negligible in size.  
C. All collisions are perfectly elastic.  
D. There is no intermolecular force between molecules except during collision.

23. A closed vessel contains an ideal gas at a certain temperature. The gas is heated until its pressure reaches 1.2 times its initial value. Calculate the percentage increase in the average kinetic energy of the gas molecules.

A. 10%  
B. 20%  
C. 44%  
D. It cannot be determined since the number of moles of gas molecules is not known.
Since the beginning of the 20th century, α-particles had been used as energetic projectiles to bombard various substances to trigger reactions. Many great discoveries came from this kind of experiments. Which of the following discoveries is NOT a nuclear reaction?

A. In the discovery of protons, α-particles were used to bombard nitrogen gas.
B. In the discovery of neutrons, α-particles were used to bombard beryllium.
C. In the discovery of artificial radioactivity, α-particles were used to transmute aluminium into phosphorus.
D. In the discovery of large angle deflection, α-particles were used to bombard gold foil.

The diagram is a plot of binding energy per nucleon for a number of naturally occurring nuclides against their mass number. Which of the following statements are correct?

(1) Of the five nuclides plotted, \(^{56}\text{Fe}\) is the most unstable.
(2) Comparing to \(^{23}\text{Na}\), it takes more energy to split \(^{27}\text{Al}\) into its individual nucleons.
(3) Energy is released if \(^{235}\text{U}\) is split into two nuclei of comparable masses.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)
Questions 26 to 45 are for AL candidates only.

26. A steel ball bearing is released from the surface of a long tube of viscous oil. In falling through the oil, the bearing experiences an opposing viscous force whose magnitude is proportional to its speed. Which of the following graphs best represents the variation of the distance fallen $s$ with time $t$?

27. Which of the following statements about geostationary orbits around the Earth are correct?

(1) There is only one geostationary orbit around the Earth.
(2) All satellites in a geostationary orbit must have the same speed.
(3) No satellite in a geostationary orbit can pass vertically above Hong Kong.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

28. The figure shows a binary star system in which $P$ and $Q$ are two stars revolving about $O$ with uniform circular motion under their mutual gravitational attraction. If the radius of the orbit of $P$ is twice that of $Q$, which of the following deductions are correct?

(1) The mass of $P$ is half that of $Q$.
(2) The orbital speed of $P$ is equal to that of $Q$.
(3) The acceleration of $P$ is twice that of $Q$.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

29. The Earth moves around the Sun with a mean orbital radius of $1.50 \times 10^{11}$ m. Which of the following is a possible planetary orbit around the Sun?

<table>
<thead>
<tr>
<th>Orbital radius (m)</th>
<th>Period (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. $13.4 \times 10^{11}$</td>
<td>11.9</td>
</tr>
<tr>
<td>B. $14.3 \times 10^{11}$</td>
<td>29.5</td>
</tr>
<tr>
<td>C. $2.85 \times 10^{11}$</td>
<td>1.9</td>
</tr>
<tr>
<td>D. $2.11 \times 10^{11}$</td>
<td>0.6</td>
</tr>
</tbody>
</table>
30. When light travels from air to glass, the polarizing angle (Brewster’s angle) in air is $56.3^\circ$. What is the polarizing angle in glass if light travels from glass to air?

A. $33.7^\circ$
B. $41.8^\circ$
C. $56.3^\circ$
D. It cannot be found as total internal reflection will occur.

31. A wire is stretched between movable bridges $P$ and $Q$ as shown. The tension in the wire can be varied by changing the weights added. Mechanical waves can be generated by plucking the wire $PQ$. Which of the following statements about the speed $v$ of the mechanical waves in the wire is/are correct?

(1) $v$ decreases if weights are added.
(2) $v$ increases if the separation $PQ$ is reduced.
(3) $v$ increases if a wire of smaller mass per unit length is used.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

32. A telescope consists of two lenses of focal lengths 2 cm and 1 m. The telescope is in normal adjustment. The diameter of the eyepiece is 3 cm. What is the maximum diameter of the objective such that all the light parallel to the principal axis collected by the objective can enter the eyepiece?

A. 3 cm
B. 30 cm
C. 60 cm
D. 150 cm

33. A car approaches a stationary observer with constant speed along a straight line. The car sounds its horn which emits sound of a fixed pitch. Which of the following statements concerning the sound received by the observer is/are correct?

(1) The wavelength of the sound waves received by the observer is shorter compared to the case when the car is stationary.
(2) The pitch of the sound heard by the observer increases when the car gets nearer the observer.
(3) The speed of the sound waves relative to the observer increases compared to the case when the car is stationary.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only
The dotted curves in the above figure represent two equipotential surfaces due to an isolated point charge. The electric potentials at P and Q are -50 V and -30 V respectively. R is the mid-point of PQ. P, Q, R and the isolated point charge are collinear. Which of the following deductions is/are correct?

1. The electric field at R is pointing towards P.
2. The electric field at R is stronger than that at P.
3. The electric potential at R is lower than -40 V.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

The primary coil of a transformer is connected to the 240 V a.c. mains and the secondary coil is connected to a 12 V 24 W bulb, which glows normally. When the laminated iron core is replaced by one of solid iron, the bulb glows dimly. Which of the following statements is/are correct?

1. There are larger eddy currents in the solid core.
2. The rate of change of magnetic flux through the solid core is reduced.
3. More energy is dissipated in the secondary coil when a solid core is used.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only
36. A capacitor of capacitance 1 \( \mu F \) is charged to a voltage of 1 kV. When the capacitor is discharged across a spark gap, the spark lasts for 4 ms. What is the average current in the spark?

- A. 0.05 A
- B. 0.1 A
- C. 0.25 A
- D. 0.5 A

37. The above figure shows an LC oscillatory circuit in which \( C \) is a parallel-plate capacitor and \( L \) is an inductor. At a certain instant, the magnetic field lines in \( L \) and the electric field lines in \( C \) are sketched as shown. At the instant shown,

- (1) the current is flowing from \( P \) to \( Q \) through \( L \).
- (2) the capacitor is discharging.
- (3) the magnitude of the current in the circuit is decreasing.

- A. (1) only
- B. (3) only
- C. (1) and (2) only
- D. (2) and (3) only

38. A 2 V cell of negligible impedance is connected to a 0.1 H inductor and a 5 \( \Omega \) resistor as shown. Find the time taken for the current to rise to 0.3 A after closing switch \( S \).

- A. 6 ms
- B. 15 ms
- C. 28 ms
- D. 69 ms
The above graph shows how the intermolecular force $F$ exerted by a molecule $P$ fixed at the origin $O$ on another molecule $Q$ along the x-axis varies with their separation $x$. $F$ is taken as positive when it is repulsive. If $Q$ is released from rest at position $X$, which of the following descriptions about its subsequent motion is/are correct?

1. $Q$ will accelerate from $X$ to $Y$ but it will decelerate from $Y$ to $Z$.
2. $Q$ will come to momentarily at rest at $Z$.
3. The intermolecular potential energy of the two molecules will decrease when $Q$ is moving from $X$ to $Z$.

A. (1) only  
B. (3) only  
C. (1) and (2) only  
D. (2) and (3) only

40.

When a 50 m steel railway track is struck by a hammer at one end $X$, the compression pulse takes 10 ms to reach the far end $Y$. If the density of steel is 7850 kg m$^{-3}$, find the Young modulus of steel.

A. $2.0 \times 10^7$ Pa  
B. $4.0 \times 10^7$ Pa  
C. $2.0 \times 10^{11}$ Pa  
D. $4.0 \times 10^{11}$ Pa

41.

The figure shows a spinning ball moving to the left in still air. Which of the following statements is/are correct?

1. The streamlines are denser at $P$ than those at $Q$.
2. The Bernoulli's force acting on the ball due to its spin points from $P$ to $Q$.
3. The pressure at $P$ is greater than that at $Q$.

A. (1) only  
B. (3) only  
C. (1) and (2) only  
D. (2) and (3) only
42. Arrange the following in ascending order of energy.

(1) kinetic energy gained by an electron when it is accelerated through a p.d. of 10 V
(2) average kinetic energy of an air molecule at room temperature
(3) kinetic energy of an α-particle emitted from the nucleus of a radionuclide

A. (3), (2), (1)
B. (1), (3), (2)
C. (2), (3), (1)
D. (2), (1), (3)

43. The human eye is most sensitive to green light of wavelength 520 nm. Our eyes can detect light of minimum intensity $2.0 \times 10^{-13}$ W m$^{-2}$. Estimate the minimum number of photons entering an eye in one second in order to cause sensation, assuming that the average diameter of the pupil is 5 mm.

(Given: Planck constant $h = 6.63 \times 10^{-34}$ J s)

A. 10000
B. 1000
C. 100
D. 10

44. The figure shows the four lowest energy levels of a hydrogen atom. It is known that the wavelength of visible light ranges from 400 nm to 700 nm and the energy of a yellow light photon (about 600 nm) is 2 eV. If electrons having kinetic energy of 12.5 eV are used to bombard a large number of hydrogen atoms, how many spectral lines in the visible region can be obtained subsequently?

A. 0
B. 1
C. 2
D. 3

45. A nucleus has mass number $A$, atomic number $Z$ and binding energy of magnitude $B$. (i.e. $B$ is positive.)

Let $m_n =$ mass of a neutron
$m_p =$ mass of a proton
$c =$ speed of light in vacuum

Which of the following expressions correctly gives the mass of the nucleus?

A. $Am_n + Zm_p + \frac{B}{c^2}$
B. $Am_n + Zm_p - \frac{B}{c^2}$
C. $(A - Z)m_n + Zm_p + \frac{B}{c^2}$
D. $(A - Z)m_n + Zm_p - \frac{B}{c^2}$

END OF SECTION A
### Useful Formulae in Advanced Level Physics

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a = \frac{v^2}{r} = \omega^2 r$</td>
<td>Centripetal acceleration</td>
</tr>
<tr>
<td>$a = -\omega^2 x$</td>
<td>Simple harmonic motion</td>
</tr>
<tr>
<td>$F = \frac{Gm_1 m_2}{r^2}$</td>
<td>Newton's law of gravitation</td>
</tr>
<tr>
<td>$U = -\frac{GMm}{r}$</td>
<td>Gravitational potential energy</td>
</tr>
<tr>
<td>$r^2 / \tau^2 = \text{constant}$</td>
<td>Kepler's third law</td>
</tr>
<tr>
<td>$\nu = \frac{T}{m}$</td>
<td>Velocity of transverse wave motion in a stretched string</td>
</tr>
<tr>
<td>$\nu = \frac{E}{\rho}$</td>
<td>Velocity of longitudinal wave motion in a solid</td>
</tr>
<tr>
<td>$n = \tan \theta_p$</td>
<td>Refractive index and polarising angle</td>
</tr>
<tr>
<td>$d = \frac{\lambda D}{a}$</td>
<td>Fringe width in double-slit interference</td>
</tr>
<tr>
<td>$d \sin \theta = n\lambda$</td>
<td>Diffraction grating equation</td>
</tr>
<tr>
<td>$f' = f \left(1 - \frac{u_0}{u - u_i}\right)$</td>
<td>Doppler frequency</td>
</tr>
<tr>
<td>$10 \log_{10} \left(\frac{I_2}{I_1}\right)$</td>
<td>Definition of the decibel</td>
</tr>
<tr>
<td>$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$</td>
<td>Equation for a single lens</td>
</tr>
<tr>
<td>$E = \frac{Q}{4\pi \varepsilon_0 r^2}$</td>
<td>Electric field strength due to a point charge</td>
</tr>
<tr>
<td>$V = \frac{Q}{4\pi \varepsilon_0 r}$</td>
<td>Electric potential due to a point charge</td>
</tr>
<tr>
<td>$E = \frac{V}{d}$</td>
<td>Electric field between parallel plates (numerically)</td>
</tr>
<tr>
<td>$C = \frac{Q}{V} = \varepsilon_0 A$</td>
<td>Capacitance of a parallel-plate capacitor</td>
</tr>
<tr>
<td>$Q = Q_0 e^{-t/RC}$</td>
<td>Decay of charge with time when a capacitor discharges</td>
</tr>
<tr>
<td>$Q = Q_0 (1 - e^{-t/RC})$</td>
<td>Rise of charge with time when charging a capacitor</td>
</tr>
<tr>
<td>$E = \frac{1}{2} CV^2$</td>
<td>Energy stored in a capacitor</td>
</tr>
<tr>
<td>$I = nA\nu \bar{Q}$</td>
<td>General current flow equation</td>
</tr>
<tr>
<td>$R = \frac{\rho l}{A}$</td>
<td>Resistance and resistivity</td>
</tr>
<tr>
<td>$F = BQ\nu \sin \theta$</td>
<td>Force on a moving charge in a magnetic field</td>
</tr>
<tr>
<td>$F = BIL \sin \theta$</td>
<td>Force on a current-carrying conductor in a magnetic field</td>
</tr>
<tr>
<td>$V = \frac{Bl}{nQl}$</td>
<td>Hall voltage</td>
</tr>
</tbody>
</table>

### Magnetic Field Formulas

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B = \frac{\mu_0 I}{2\pi r}$</td>
<td>Magnetic field due to a long straight wire</td>
</tr>
<tr>
<td>$B = \frac{\mu_0 N I}{l}$</td>
<td>Magnetic field inside a long solenoid</td>
</tr>
<tr>
<td>$F = \frac{\mu_0 I_1 I_2}{2\pi r}$</td>
<td>Force per unit length between long parallel straight current-carrying conductors</td>
</tr>
<tr>
<td>$T = BANI \sin \phi$</td>
<td>Torque on a rectangular current-carrying coil in a uniform magnetic field</td>
</tr>
<tr>
<td>$E = BAN \nu \sin \omega t$</td>
<td>Simple generator e.m.f.</td>
</tr>
<tr>
<td>$\frac{V_s}{V_p} = \frac{N_s}{N_p}$</td>
<td>Ratio of secondary voltage to primary voltage in a transformer</td>
</tr>
</tbody>
</table>

### Electromagnetic Induction Formulas

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon = -\frac{dI}{dt}$</td>
<td>E.m.f. induced in an inductor</td>
</tr>
<tr>
<td>$E = \frac{1}{2} LI^2$</td>
<td>Energy stored in an inductor</td>
</tr>
<tr>
<td>$X_L = \omega L$</td>
<td>Reactance of an inductor</td>
</tr>
<tr>
<td>$X_C = \frac{1}{\omega C}$</td>
<td>Reactance of a capacitor</td>
</tr>
<tr>
<td>$P = IV \cos \theta$</td>
<td>Power in an a.c. circuit</td>
</tr>
</tbody>
</table>

### Thermodynamics and Kinetic Theory Formulas

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$pV = nRT = NkT$</td>
<td>Equation of state for an ideal gas</td>
</tr>
<tr>
<td>$pV = \frac{1}{3} Nm_c^2$</td>
<td>Kinetic theory equation</td>
</tr>
<tr>
<td>$E_k = \frac{3RT}{2N_A} = \frac{3}{2} kT$</td>
<td>Molecular kinetic energy</td>
</tr>
<tr>
<td>$E = \frac{F}{A} \frac{x}{L}$</td>
<td>Macroscopic definition of Young modulus</td>
</tr>
<tr>
<td>$F = -\frac{dU}{dr}$</td>
<td>Energy stored in stretching</td>
</tr>
<tr>
<td>$P + \frac{1}{2} \rho v^2 + \rho gh = \text{constant}$</td>
<td>Relationship between force and potential energy</td>
</tr>
</tbody>
</table>

### Energy Level and Decay Formulas

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta U = Q + W$</td>
<td>First law of thermodynamics</td>
</tr>
<tr>
<td>$E_n = -\frac{13.6}{n^2}$ eV</td>
<td>Energy level equation for hydrogen atom</td>
</tr>
<tr>
<td>$N = N_o e^{-\frac{t}{t_h}}$</td>
<td>Law of radioactive decay</td>
</tr>
<tr>
<td>$t_h = \frac{\ln 2}{k}$</td>
<td>Half-life and decay constant</td>
</tr>
<tr>
<td>$\frac{1}{2} mv_n^2 = \hbar^2 - \Phi$</td>
<td>Einstein's photoelectric equation</td>
</tr>
<tr>
<td>$E = mc^2$</td>
<td>Mass-energy relationship</td>
</tr>
</tbody>
</table>