Important Concepts of Physics

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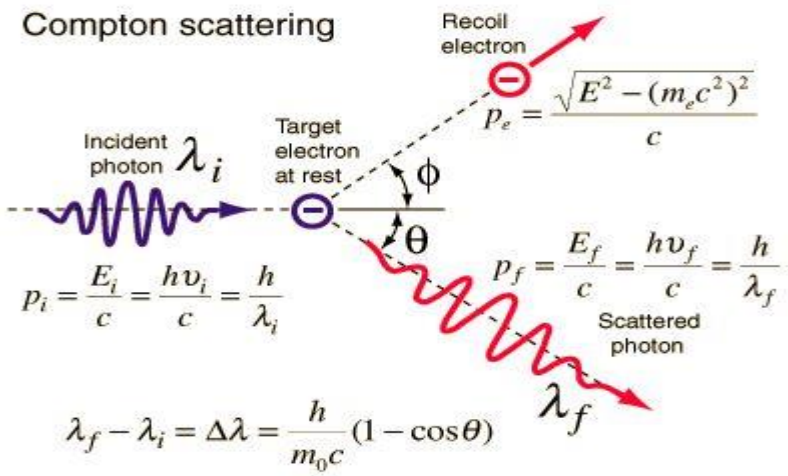
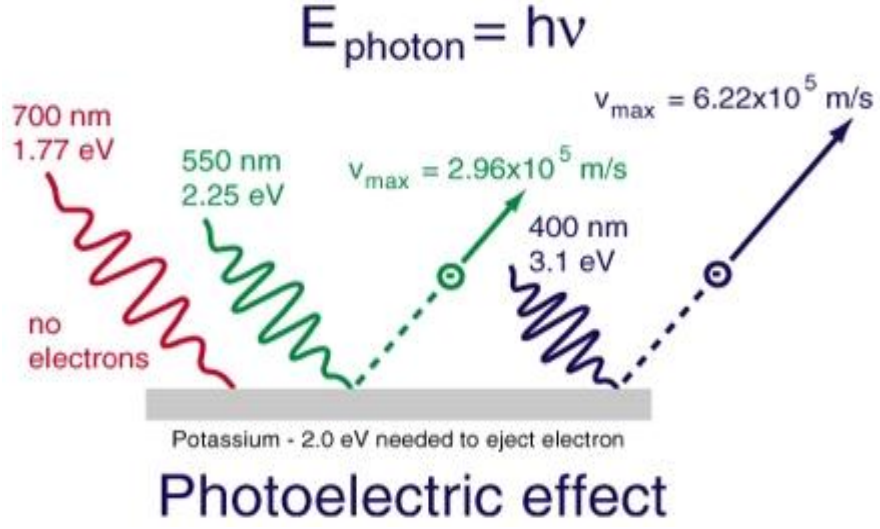
1. **Compton Effect: Increase in wavelength of X-rays & other electromagnetic radiations that have been elastically scattered by an electron; it is one of the principal way in which radiant energy is absorbed in matter.** The Colours in the diagram has their own significance. If we follow VIBGYOR & for a photon E = hν (h c / λ) ; Red Photon is of MAX λ, so, MIN Energy & VIOLET is of MIN λ, so, MAX Energy. In the diagram below applying the above concept, it is obvious that incident Photon is of more energy and the energy of scattered photon is lesser, the difference of energy is transferred to electron (since energy has to be conserved). **Δλ is defined as Compton Shift. The whole concept is based on conservation of Energy & Momentum.**



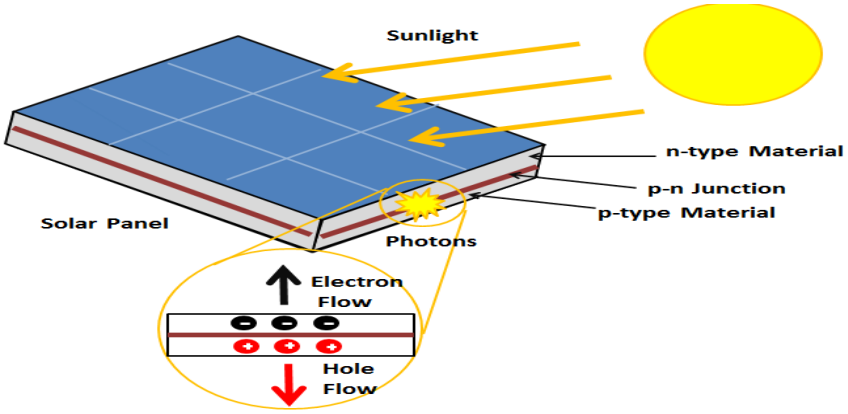
1. **Photoelectric Effect: Phenomenon in which electrically charged particles are released from or within a photosensitive material when it absorbs electromagnetic radiation. The Colours in the diagram has their own significance. If we follow VIBGYOR & for a photon E = h c / λ ; Red Photon is of MAX λ , so, MIN Energy & VIOLET is of MIN λ, so, MAX Energy & Similarly for GREEN is in between. As per Einstein's concept of PEE the incident photon should have sufficient energy for Photo Electric Effect. From diagram, for obvious reasons as explained above there is NO PEE for RED colour. However, there is PEE in case of Green & Violet and the excess of energy is associated with the emitted electron. Further it is clear that Energy of emitted Electron in case of Violet is more as compared to Green, for obvious reasons.**



Assume the number of photons of RED are 1000 & that of Violet are just 100, even than there is NO PEE in case of RED and will happen in case of VIOLET only, this verifies that PPE depends on the energy of incident photon rather than the intensity of incident light (number of photons). The effect is often defined as the ejection of electrons from a metal plate when light falls on it. In a broader definition, the radiant energy may be infrared, visible,

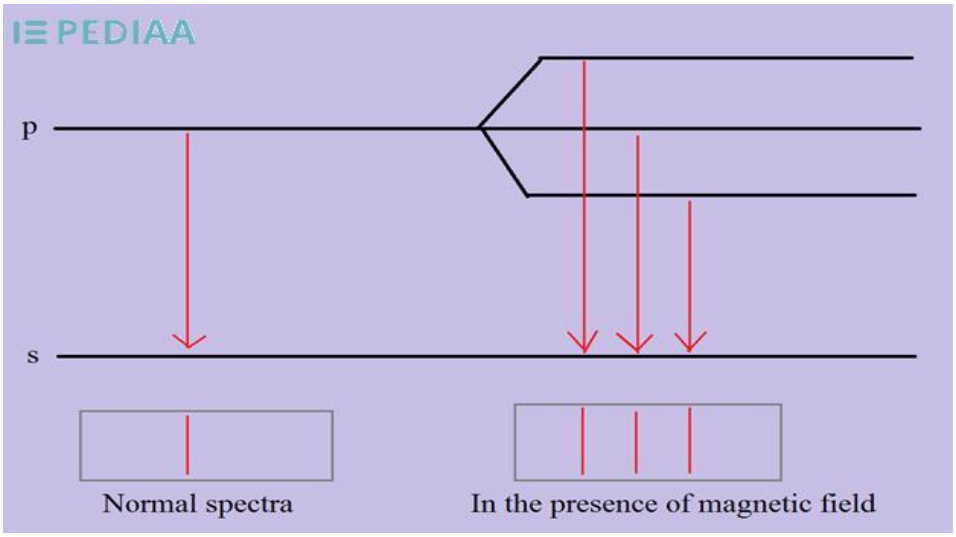
or ultraviolet light, X rays or gamma rays; the material may be a solid, liquid, or gas; and the released particles may be ions (electrically charged atoms or molecules) as well as electrons. One inexplicable observation was that the maximum kinetic energy of the released electrons did not vary with the intensity of the light, as expected according to the wave theory, but was proportional instead to the frequency of the light. Light intensity did determine was the number of electrons released from the metal (measured as an electric current) that also only if energy of incident photon is more than work function of the photosensitive material. Another puzzling observation was that there was virtually no time lag between the arrival of radiation and the emission of electrons implies the phenomena is instantaneous.

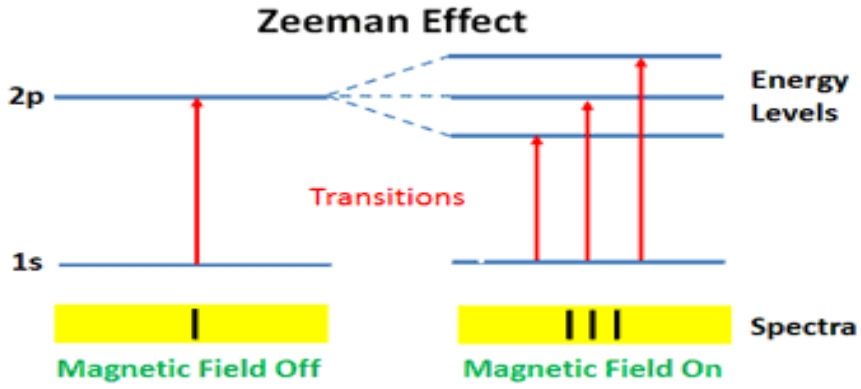
2. **Photovoltaic Effect:** Process in which two dissimilar materials in close contact produce an electrical voltage when struck by light or other radiant energy. Light striking crystals such as silicon or germanium, in which electrons are usually not free to move from atom to atom within the crystal, provides the energy needed to free some electrons from their bound condition. Free electrons cross the junction between two dissimilar crystals more easily in one direction than in the other, giving one side of the junction a negative charge and, therefore, a negative voltage with respect to the other side, just as one electrode of a battery has a negative voltage with respect to the other. The photovoltaic effect can continue to provide voltage and current as long as light continues to fall on the two materials. This current can be used to measure the brightness of the incident light or as a source of power in an electrical circuit, as in a solar power system.



On the other hand, whenever two different materials are placed in contact, an electric field is generated along the contact. This is the so-called built-in field, and it exerts a force on free electrons, effectively "tilting" the electron states and forcing the excited free electrons into an external electrical load where their excess energy can be dissipated. The external load can be a simple resistor, or it can be any of a myriad of electrical or electronic devices ranging from motors to radios. Finally, when the excess energy is utilized, the electron is back in the ground state. The photovoltaic effect produces a direct current (DC).

3. **Zeeman Effect: We all are aware, that there is resultant magnetic field in an atom contributed by orbital & spin motion of electrons. That means atoms will respond to external magnetic field. The splitting of a spectral line into two or more components of slightly different frequency when the light source is placed in a magnetic field. It was first observed in 1896 by the Dutch physicist Pieter Zeeman as a broadening of the yellow D-lines of sodium in a flame held between strong magnetic poles.**





Later the broadening was found to be a distinct splitting of spectral lines into as many as 15 components. Zeeman's discovery earned him the 1902 Nobel Prize for Physics, which he shared with a former teacher, Hendrik A Lorentz, another Dutch physicist.

Lorentz, who had earlier developed a theory concerning the effect of magnetism on light, hypothesized that the oscillations of electrons inside an atom produce light and that a magnetic field would affect the oscillations and thereby the frequency of the light emitted. This theory was confirmed by Zeeman's research and later modified by quantum mechanics, according to which spectral lines of light are emitted when electrons change from one discrete energy level to another. Each of the levels, characterized by an angular momentum (quantity related to mass and spin), is split in a magnetic field into substates of equal energy. These

substates of energy are revealed by the resulting patterns of spectral line components.

5.Seebeck Effect: Production of an electromotive force (emf) and consequently an electric current in a loop of material consisting of at least two dissimilar conductors when two junctions are maintained at different temperatures.

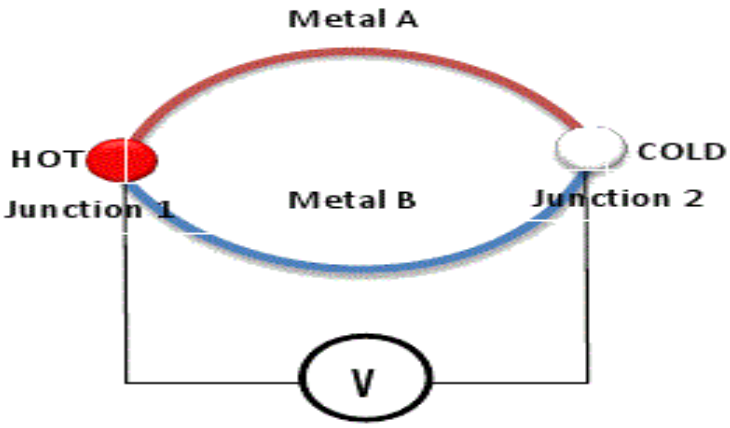
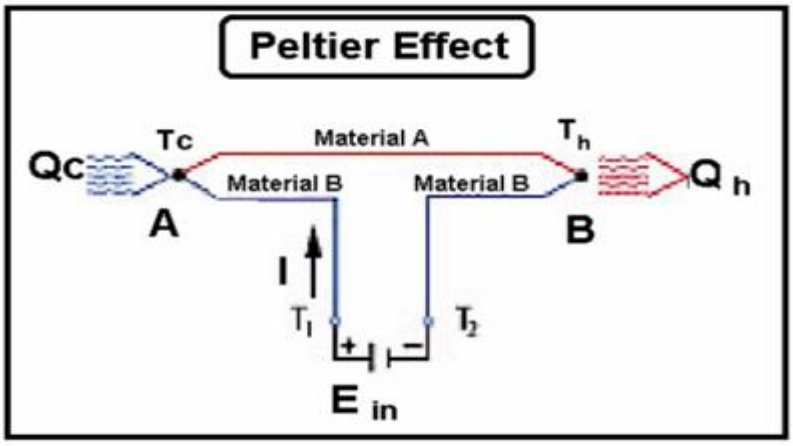


Figure 1: Seebeck effect

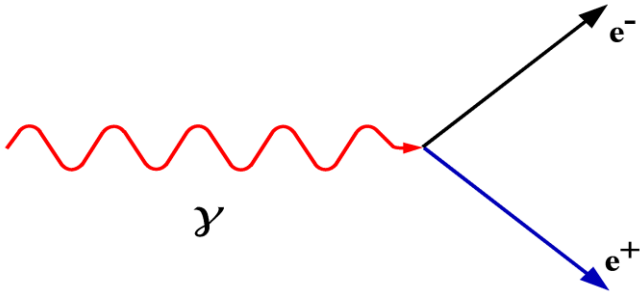
The conductors are commonly metals, though they need not even be solids. The German physicist Thomas Johann Seebeck discovered (1821) the effect. The Seebeck effect is used to measure temperature with great sensitivity and accuracy using thermocouples and to generate electric power for special applications.

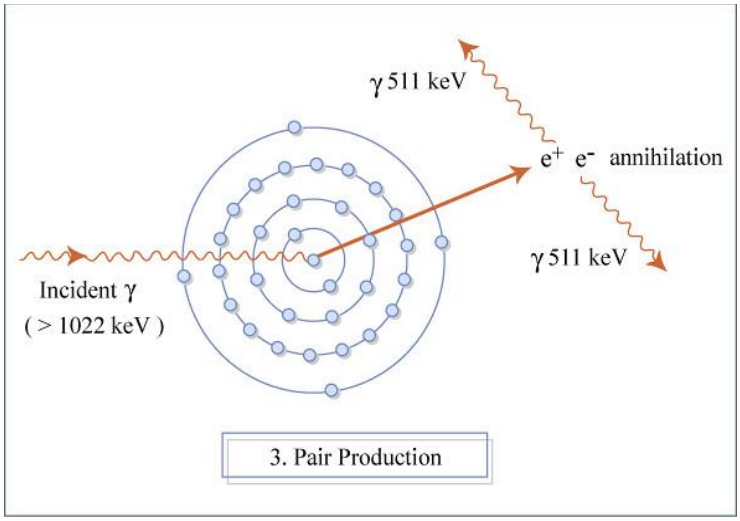
6.Peltier Effect: Reverse of Seebeck effect. The cooling of one junction and the heating of the other when electric current is maintained in a circuit of material consisting of two dissimilar conductors; the effect is even stronger in circuits containing dissimilar semiconductors. In a circuit consisting of a battery joined by two pieces of copper wire to a length of bismuth wire, a temperature rises at the junction where the current passes from copper to bismuth, and a temperature drop occurs at the junction

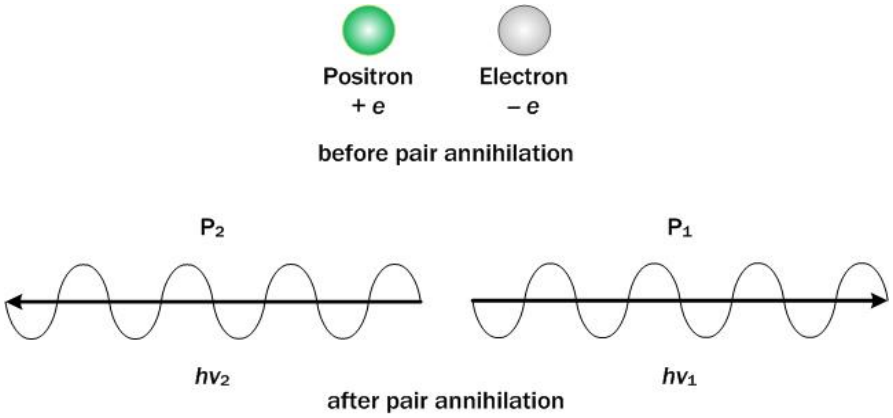
where the current passes from bismuth to copper. This effect was discovered in 1834 by the French physicist A Peltier.



7. **Pair Production & Annihilation : Formation of two electrons, one negative and the other positive (positron), from a pulse of electromagnetic energy traveling through matter, usually in the vicinity of an atomic nucleus. Pair production is a direct conversion of radiant energy to matter. It is one of the principal ways in which high-energy gamma rays are absorbed in matter. For pair production to occur, the electromagnetic energy, in a discrete quantity called a photon, must be at least equivalent to the energy-mass equivalence of two electrons. The mass *m* of a single electron is equivalent to 0.51 MeV of energy *E* as calculated by Einstein equation, $E = mc^2$, in which *c* is a constant equal to the velocity of light. To produce two electrons, therefore, the photon energy must be at least 1.02 MeV. Photon energy in excess of this amount, when pair production occurs, is converted into motion of the electron-positron pair. If pair production occurs in a track detector, such as a cloud chamber, to which a magnetic field is properly applied, the electron and the positron curve away from the point of formation in opposite directions in arcs of equal curvature. The positron that is formed quickly disappears by reconversion into photons in the process of annihilation with another electron in matter.**

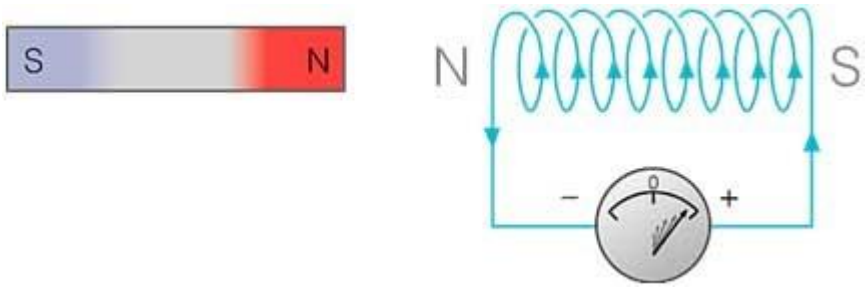




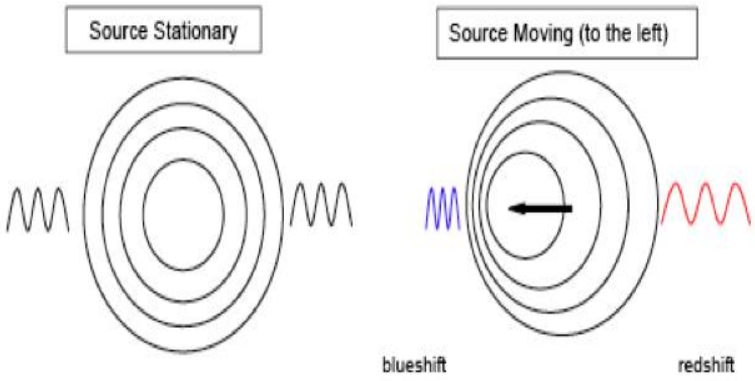


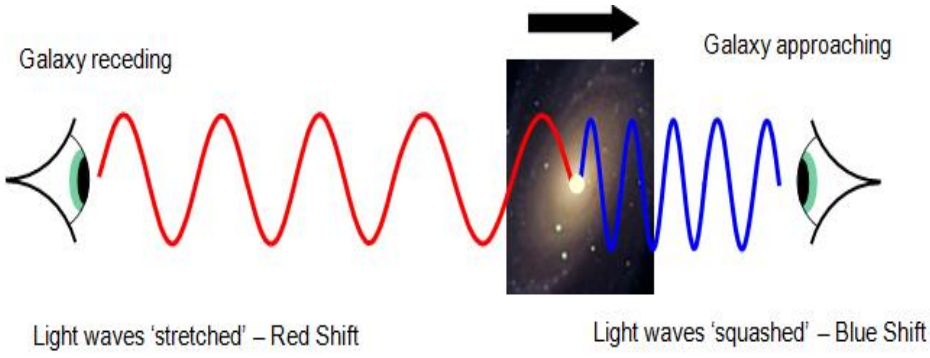
8. <u>Faraday's Laws of EMF:</u> **Whenever there is a relative motion between the magnet & the coil, the galvanometer shows deflection. Faster the motion more is the current, the induced emf is such that the current in the coil gives rise to North polarity, as shown in the diagram. If the magnetic is moved away from the coil, the coil develops South**

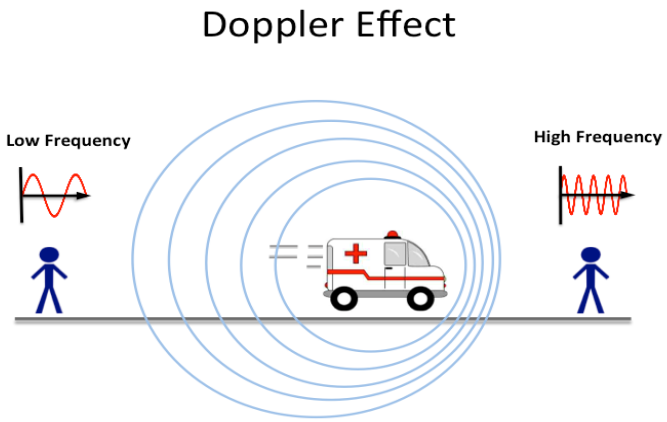
polarity. The extent of deflection is Explained by Faraday & the direction is explained by Lenz.



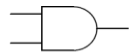
9. **<u>Doppler effect:</u> Whenever there is a relative motion between the Sound Source & Listener or Light Source & Observer, the Apparent frequency / Apparent wavelength is different than the actual Frequency / Wavelength. All the figures below are explanation for Doppler Effect of Sound or Light.**





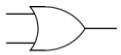


10. Logic Operations with two HEX numbers.



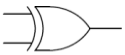
AND

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1



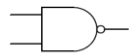
OR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1



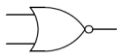
XOR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0



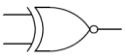
NAND

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0



NOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0



XNOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1

Solution: Let's understand Gates on a different track. For example somebody asks you, in S.Y. B.Sc how many subjects you had. Your logical answer will be (Physics AND Maths) OR (Physics AND Chemistry) = True, see the use of Gates. For AND both the conditions have to be true while for OR any one can be true. The AND & OR Gates are Valid at the respective places. Similarly assume in any program a couple only is allowed, in that case XOR is the more suitable gate, as both the inputs if of different nature leads to high (0,1 & 1,0).

To Summarize:

a. **For O/P of AND gate to be high, both the conditions has to be satisfied or true.**
b. **For O/P of OR gate to be high, minimum any one condition**

has to be satisfied or true.

c. For output of XOR gate to be high, both the conditions have to different i.e complement of each other.

d. NOR, NAND & NXOR are nothing but gates with complementary output of OR, AND & XOR gates respectively.

e. However, NAND & NOR gates are called Universal gates, using them you can configure any gates.

f. Let's consider two arbitrary Hex Numbers, 4C & D7

Logical Operation	Binary	Hex
----------	0100 1100	4C
----------	1101 0111	D7
AND	01000100	44
OR	11011111	DF
XOR	10011011	9B

11. R P S: Stepdown, Rectification, Filtration & Regulation & Pulsating DC, Smooth DC & Regulated DC

Solution:

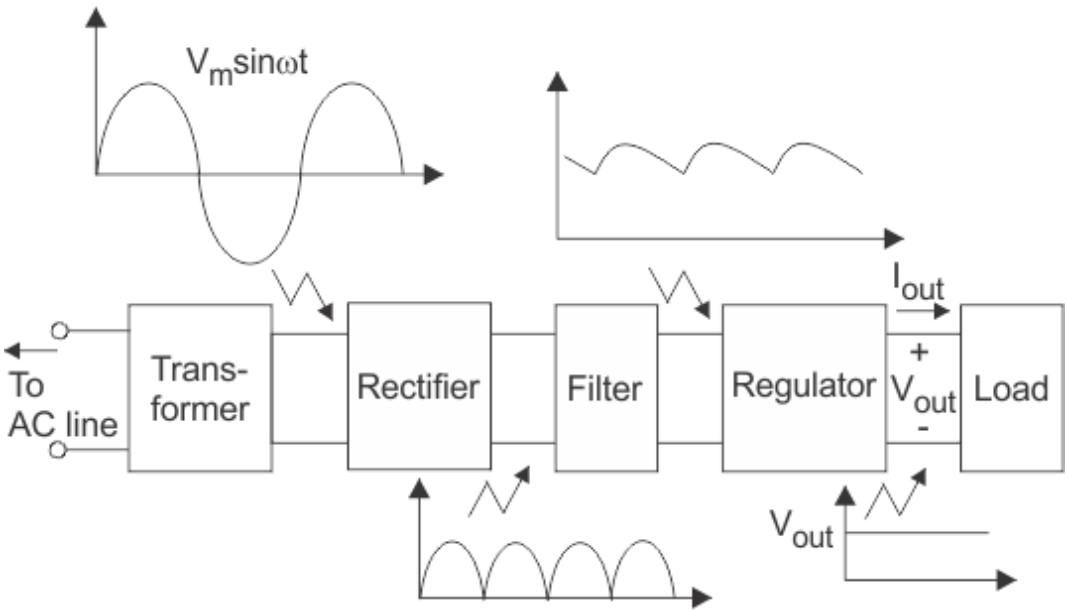
Regulated Power Supply: An RPS converts AC (Alternating Current) to DC (Direct Current). An RPS is used to ensure that the output voltage remains constant even if the input vary or the load vary. The figure above shows the block diagram of a typical regulated DC power supply. The basic building blocks of RPS are as follows:

a) A step-down transformer
b) A rectifier
c) A DC filters
d) A regulator

Operation of Regulated Power Supply: A stepdown transformer will step down the voltage from the ac mains to the required voltage level. The output of the transformer is given as an input to the rectifier circuit.

Rectification is the process of converting an alternating voltage or current into corresponding direct (DC) quantity. The input to a rectifier is AC whereas its output is unidirectional pulsating DC.

The rectified voltage from the rectifier is a pulsating DC voltage having very high ripple content. However, we want a pure ripple free DC waveform. Hence a filter is used. Different types of filters are used such as capacitor filter, LC filter, Choke input filter, π type filter.



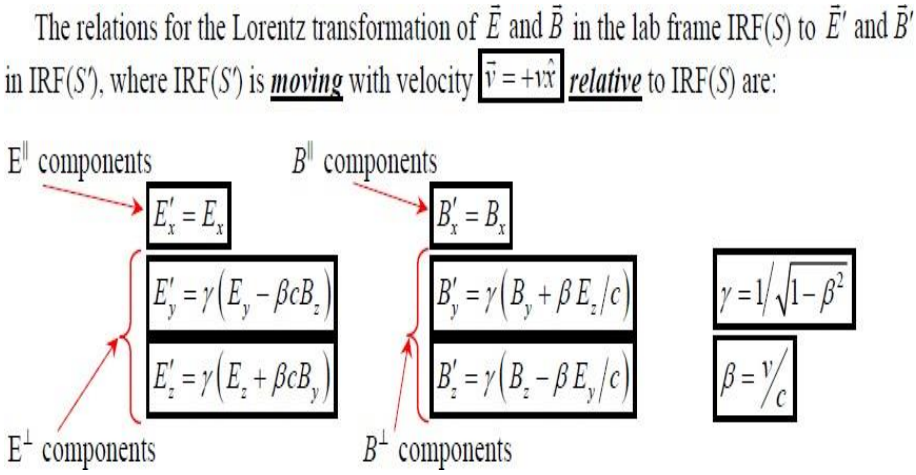
Components of typical linear power supply

The output voltage or current will fluctuate when there is a change in the input from ac mains or due to change in load current at the output of the regulated power supply or due to other factors like temperature changes. This problem can be eliminated by using a regulator. A regulator will maintain the output constant even when changes at the input or any other changes occur. Transistor series regulator, Fixed and

variable IC regulators or a Zener diode operated in the Zener region can be used depending on their applications. IC's like 78XX and 79XX (such as the IC 7805) are used to obtained fixed values of voltages at the output & IC's like LM 317 and 723, we can adjust the output voltage to a required constant value.

12. Interdependence of E & B Under Relativity:

Solutions: We all know the electric charge at rest produces Electric Field & a moving charge produces Magnetic Field. It is usually assumed that Magnetic & Electric Fields are independent of each other. But the truth is they are interdependent. Refer the expressions below, the components of E & B in one frame of reference are a MIX of E & B in other frame of reference. The frame S' is moving with a constant velocity v with respect to frame S. We can have inverse transformation equations also just replace v by -v.



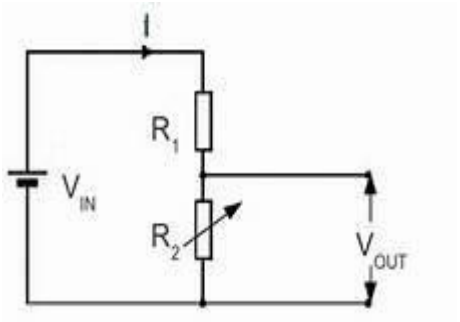
13. Concept of Potential Divider, Extended to LPF & HPF.

Solution: All diagrams below are PDA, let's understand the significance of each of them. Refer diagram (A): Let R1= 5KΩ (fixed) & R2 is a 100KΩ Pot i.e a variable resistance, further let VIN = 10 Volts. Now the Voltage VOUT will vary with R2 as below: VOUT = [VIN / R1 + R2] x R2

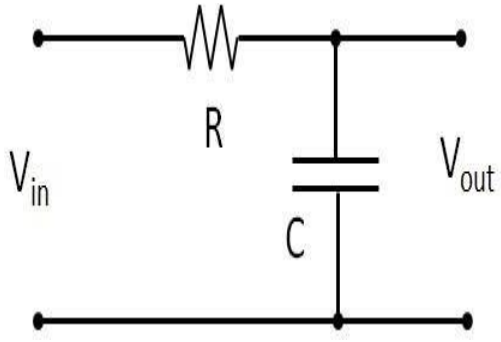
Implies as R2 ↑ VOUT ↑ & Reverse as R2 ↓ VOUT ↓

Sr No	R2	VOUT
1	5	3.33
2	25	7.14
3	45	8.18
4	65	8.66
5	85	8.95

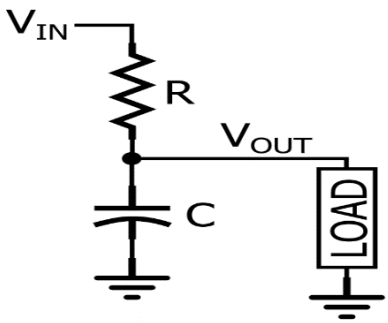
Diagrams (B), (C) & (D) all are cousins of (A)



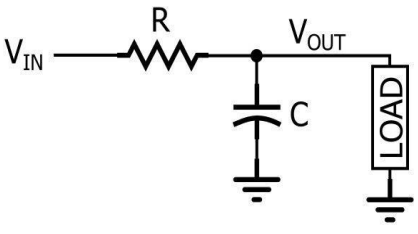
(A)



(B)



(C)

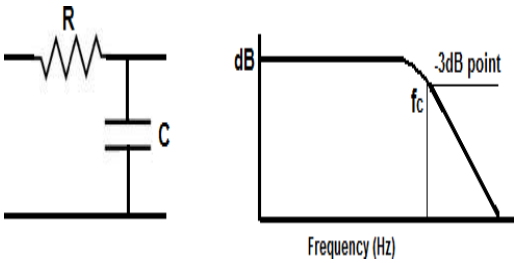


(D)

Let's see how: R1 is replaced by R, R2 is replaced by C and further let VIN which was DC is replaced by AC. And the LOAD is replaced by a AC Voltmeter or CRO. Moreover, we Know XC = 1/2πfC

Now if you vary frequency of AC supply, keeping the voltage constant, XC will vary, rather XC ↓ as f ↑. So, at lower frequencies f is less XC will be much more compared to R so $V_{OUT} \approx V_{IN}$. Now with ↑in frequency XC will ↓ and at sufficiently high frequency XC <<< than R, $V_{OUT} \rightarrow 0$.

Implies the circuit gives sufficient V_{OUT} at low frequency and drops to ZERO at high frequency. It is Low Pass Filter. U interchange the position of R & C it becomes High Pass filter. Diagram (E) shows the frequency response of LPF.

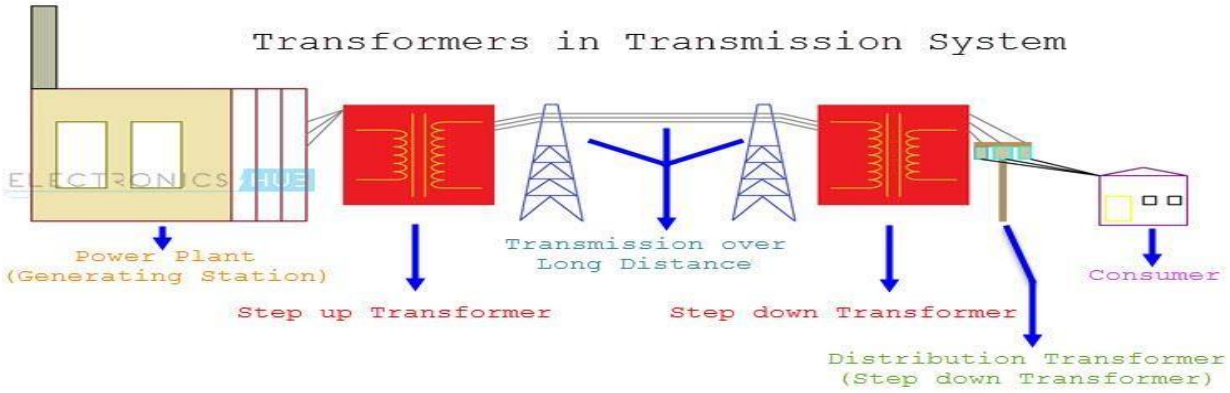


(E)

14. Transformer; a Magical Device: Explain.

Solution: Stepdown Transformer

A Transformer is a static apparatus, with no moving parts, which transforms electrical power from one circuit to another with changes in voltage and current and no change in frequency. There are two types of transformers classified by their function: Stepup & Stepdown Transformer. A Stepup Transformer is a device which converts the low primary voltage to a high secondary voltage i.e. it steps up the input voltage. A Stepdown Transformer on the other hand, steps down the input voltage i.e. the secondary voltage is less than the primary voltage. The following images shows a simple demonstration of the use of Transformers (both Step up and Stepdown Transformers) in a typical Transmission System.

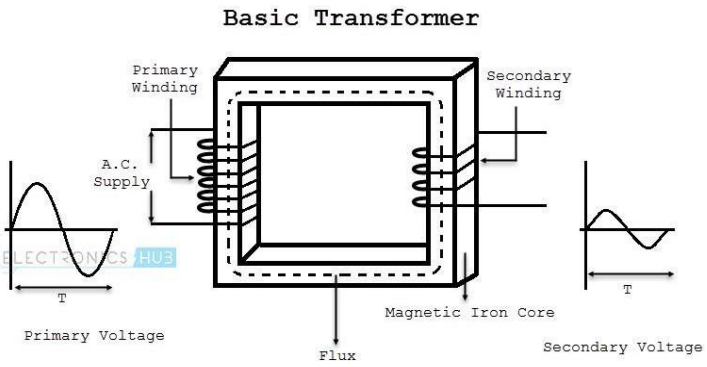


Real Time Application of Transformer

The voltage from the Power Plant or Generation Station is around 20kV. In order to transmit this voltage over long distances, it is stepped up to 440kV using a Stepup Transformer (with increase in voltage current decreases hence i^2rt i.e heat loss decreases). This voltage with increased levels is then transmitted to a distribution station. At the distribution station, the 440kV is reduced to 11kV using a Stepdown Transformer. The voltage with decreased level is then made ready for consumer use.

An electrical transformer works on the principle of Mutual Induction, which states that a change in current in a coil will induce an E.M.F in the other coil which is inductively coupled to the first coil.

In its basic form, a transformer consists of two coils with high mutual inductance that are electrically separated but have common magnetic circuit. The following image shows the basic construction of a Transformer.



The first set of the coil, which is called as the Primary Coil or Primary Winding, is connected to an alternating voltage source called Primary Voltage. The other coil, which is called as Secondary Coil or Secondary Winding, is connected to the load and the load draws the resulting alternating voltage (stepped up or stepped down voltage). The alternating voltage at the input excites the Primary Winding, an alternating current circulates the winding. The alternating current will result in an alternating magnetic flux, which passes through the iron magnetic core and completes its path. Since the secondary winding is also linked to the alternating magnetic flux, according to Faraday's Law, an E.M.F is induced in the secondary winding. The strength of the voltage at the secondary winding is dependent on the number of windings through which the flux gets passed through. Thus, without making an electrical contact, the alternating voltage in the primary winding is transferred to the secondary winding.

Depending on the construction of the transformer, the voltage at the secondary of the transformer may be equal, higher or lower than that at the primary of the transformer but the time period of the voltage i.e. its frequency will not change. Let NP be the number of turns of the coil in the Primary Winding and NS be the number of turns of the coil in the Secondary Winding. If the alternating voltage at the primary side of the transformer is VP and the alternating voltage at the secondary side of

the transformer is VS, then the relation between the voltages at primary and secondary and number of turns of the coil in primary and secondary is given as follows.

$$VP/VS = NP/NS$$

Example: Let NP is primary winding turns = 30000 & NS is secondary winding turns = 150. Let VP is voltage at the primary winding of the transformer = 240V. VS? Using the above equation, VS = (VP * NS)/NP = 240*150/3000 = 12V. Hence, the voltage at the secondary winding of the transformer is 12V, which is less than that at the primary. Therefore, the transformer in this subject is a Stepdown Transformer.

The power in a transformer is measured using the product of voltage and current. The power in a transformer is rated in Volt – Amps VA (or Kilo Volt – Amps kVA for larger transformers). Ideally, the power in any transformer is constant i.e. the power available at the secondary of the transformer is same as the power at the primary of the transformer.

This is even applicable to a stepdown transformer. But, since the voltage at the secondary of a stepdown transformer is lesser than that at the primary, the current at the secondary will be increased in order to balance the total power in the transformer.

Let VP be the voltage at the primary, IP be the current at the primary and PP be the power at the primary side of the transformer. Hence, the power at the primary side of the transformer is given by

$$PP = VP * IP$$

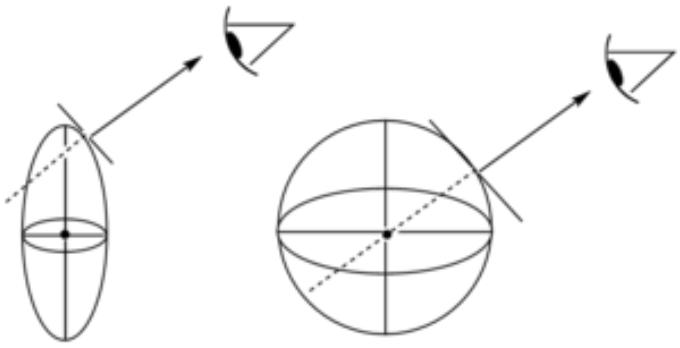
Similarly, let V_S be the voltage at the secondary, I_S be the current at the secondary and P_S be the power at the secondary side of the transformer. The power at the secondary of the transformer is given by

$P_S = V_S * I_S$. Since, the power in a transformer is constant,

$P_P = P_S$. Which means, $V_P * I_P = V_S * I_S$

As V_S is less than V_P in a stepdown transformer, I_S has to be more than IP. Hence, the output voltage in a stepdown transformer is less than that of the primary voltage and the output current is more than the input current. From the above analysis, we can define a Stepdown transformer as a device which converts a High Voltage and Low Current alternating source to a Low Voltage and High Current alternating supply. The above power calculation is for an ideal transformer where there are no loses. Practically, there will loses in the form of iron losses and copper losses that should be taken in to consideration (even though the losses are small). All the street transformers which we see near our homes are step down transformers. They take a 11kV alternating voltage at the primary and convert it to 230V for distributing it to our homes.

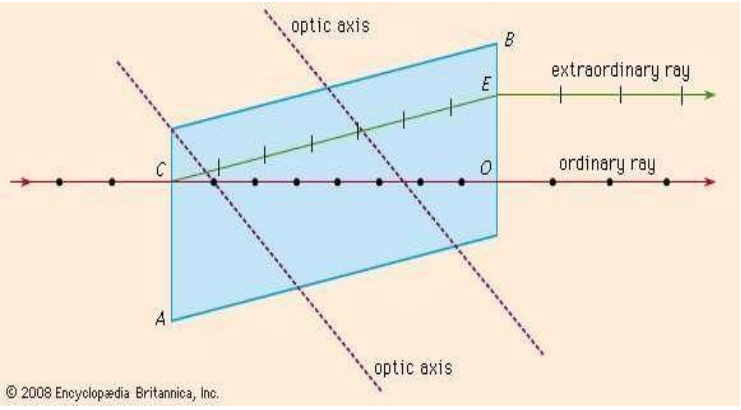
15.If Ellipsoid is the Sphere & Vice Versa in D.R



Double refraction, also called birefringence, an optical property in

which a single ray of unpolarized light entering an anisotropic medium is split into two rays, each traveling in a different direction. One ray (called the extraordinary ray) is bent, or refracted, at an angle as it travels through the medium; the other ray (called the ordinary ray) passes through the medium unchanged.

Double refraction can be observed by comparing two materials, glass and calcite. If a pencil mark is drawn upon a sheet of paper and then covered with a piece of glass, only one image will be seen; but if the same paper is covered with a piece of calcite, and the crystal is oriented in a specific direction, then two marks will become visible.



The Figure shows the phenomenon of double refraction through a calcite crystal. An incident ray is seen to split into the ordinary ray CO and the extraordinary ray CE upon entering the crystal face at C. If the incident ray enters the crystal along the direction of its optic axis, however, the light ray will not become divided. According to Huygens's theory, a point in a doubly refracting or birefringent crystal produces 2 types of wave fronts: The wave front corresponding to the O-ray is Spherical wave front & the ordinary wave travels with same velocity in all directions. The wave front corresponding to the E-ray is Ellipsoidal wave front & extraordinary waves have different velocities in different directions. Negative crystals are crystals in which refractive index

corresponding to E-Ray is less than the refractive index corresponding to O-Ray in all directions except for Optic axis, hence the E-Ray travels faster than O-Ray except along the Optic axis. The spherical O-Wave front is entirely within the ellipsoidal E -Wave front. Ex: Calcite, Tourmaline, Ruby etc. Positive crystals are crystals in which refractive for O-Ray is less than that for E- Ray. The velocity of O-Ray is greater than or equal to the velocity of E-Ray. The ellipsoidal E-wave front is entirely within the spherical O- wave front. Example: Quartz (SiO_2), Sellaite (MgF_2), Rutile (TiO_2) etc. Optic axis of a crystal is the direction in which a ray of transmitted light suffers no birefringence (double refraction). Light propagates along that axis with a speed independent of its polarization. For all rays not traveling along the optic axis, the velocity is determined by a pair of refractive indices called the ordinary refractive index no and the extraordinary refractive index ne, and the path of an incident ray is split into two rays, the so- called o-rays and e-rays. According to number of optic axes crystals are divided as: Uniaxial and Biaxial crystal.

16. Concept Behind the Vernier or Circular Scale of:

a) Screw Gauge (LC = 0.001cm)

b) Vernier Calliper (LC = 0.01cm)

c) Travelling Microscope (L.C =0.001cm)

d) Spectrometer (LC = 0.5´)

e) Michelson Interferometer (LC = 0.00001cm)

Solution: What is the Minimum Correct Measurement one can do with a Scale? The Answer is 1mm. Now if some dimension is 3.6 mm or 3.64 mm, how to Measure? For these two measurements we need to divide 1mm into 10 & 100 parts Respectively, which is Practically Impossible. The Magic is done by Vernier & Circular Scale of Vernier Callipers & Micrometre Screw Gauge. We all know in a MSG when Circular Scale takes one Complete

Round the Main scale moves ahead by only one Division (1mm) , indirectly 1mm is divided into 100 parts & hence if Circular Scale moves only by one division the measurement is [0] + {1} x (1/100) mm is 0.01mm or 0.001cm. Similarly; [5] + {68} x (1/100) = 5. 68 mm. [5]; is the Main Scale Reading which would be Possible by Simple Scale also, {66} is the Circular Scale Reading; & (1/100); is the Least Count of the Device. Hence any Measurement is possible up to 1/100 of a mm. Same Concept is valid in Travelling Microscope. In case of VC where the Least Count (the minimum measurement the device can do) is 0.1mm / 0.01 cm.

Similarly, in Spectrometers the least count is in Seconds, because with Protractor we can Correctly measure not Lesser than 1^{o}.

In Some Instruments, Like Michelson Interferometer, we have One Main & Two Vernier Scales. In this case 1/100 mm is possible with First Vernier, for the second Vernier First Vernier acts a Main Scale and Further gives a least count of 1/100 mm, hence the least count is 1/10000 mm, that is 0.0001mm or 0.00001cm that is $1x10^{-5}$ cm, if the main scale reading is 6, than the actual reading is 6×10^{-5}cm or 6000×10^{-8} cm or 6000×10^{-10} m that is 6000Å. The Instrument is used to measure the Wave length or difference in two close wavelengths. Most accurate device among all mentioned above.

Any of the above Devices if shows any reading without any object being inserted implies there is ZERO Error, depending on the type of ZE, Positive or Negative, the Error is Subtracted or Added from the Actual reading. For example, you are weighing your weight on a Digital Weighing Machine & before you load yourself the reading on the machine is -5 kg, you need to

add 5kg in your weight shown by the Machine. Similarly, if it shows +5kg before you load yourself, you need to Subtract it from the weight shown by the machine for your Actual weight. However, in case of Travelling Microscope & Michelson Interferometer we don't have the concept of

ZERO Error as we Rely on the difference of the readings so Error if any, gets Eliminated Automatically, exactly as constant of Integration gets Eliminated in case of Definite Integrals.

17. **Why it is necessary to have Colour Code on Carbon Resistors. Find CC of 100Ω, 220Ω, 22Ω, 2.2Ω & 0.22Ω);**

Solution: The Colour Code on Carbon Resistors is to find their Correct Values in the Circuits. In a Circuit a Resistor may be in Parallel with many other Components hence will have Different Effective Value & since it is Soldered, DMM CANNOT Measure the Correct value. More the Colour Rings are around the Resistor so can be seen from Anywhere.

CC of:

100Ω: Brown Black Brown

220Ω: Red Red Brown

22Ω: Red Red Black

2.2Ω: Red Red Gold

0.22Ω: Red Red Silver

18. **Free Fall Under Gravity; is a Uniform Motion? A big NO.**
19. **Find the Distance Covered by a Free-Falling Body Under Gravity left from Rest, in 3 secs? Find the distance Covered in 1^{st}, 2^{nd}, 3^{rd} Sec.**

Lets' Understand the motion under Gravity with the above Example:

Total height covered is $S = ut + \frac{1}{2} at^2$; $S = 0 + \frac{1}{2}\ 9.8 \times 3^2 = 44.1$m & the Velocity attained after three seconds is $V = u + at$; $0 + 9.8 \times 3 = 29.4$ m/s , However distance covered in 1^{st}, 2^{nd}, 3^{rd} seconds are, 4.9 m, 19.6 m & 24.5 m respectively.

Distance covered in one second, S_1= ut + ½ at^2; 0 + ½ 9.8 x 1^2= 4.9 m

Distance covered in two seconds, S_2= ut + ½ at^2; 0 + ½ 9.8 x 2^2= 19.6 m

Distance covered in three seconds, S_3= ut + ½ at^2; 0 + ½ 9.8 x 3^2= 44.1 m

Distance covered in 1^{st} second = 4.9 m,

Distance covered in 2^{nd} second; 19.6 – 4.9 =14.7m

Distance covered in 3^{rd} second; 44.1 – 19.6 = 24.5 m Respectively.

A Common Person thinks that distance covered in 1^{st}, 2^{nd}, 3^{rd} seconds Each Equal to 44.1/3 = 14.7m. This would be possible if the body would be moving with constant velocity, however the body under Gravity is Under Acceleration, it's Velocity is NOT constant rather it is Changing at Every Instant.

20. Einstein's Velocity Addition Formula; A Magical Expression!!

<u>Solution:</u> Once it was Realised that NO Velocity can be more than C; the Velocity of Light. It was necessary to develop a formula of Velocity Addition under Relativity. As per Non-Relativistic Classical Mechanics, a man running at a speed of U= 20m/sec in a train, which in turn is moving with V= 60m/sec Appears to be running with a Speed of W= U+V= 80 m/sec, for a person Standing on the Platform. Now if the Velocities are↑ to U= 0.4 C & V= 0.8C, then Non-Relativistic Classical Formula will lead to W= 1.2C which is more than C, NOT permissible. Now the Einstein's Velocity Addition Formula comes into Picture.

The Formula says W = (U + V) / [1+ UV/C^2], hence the Answer is 1.2 C/ 1+ 0.32 C^2/C^2

1.2 C / 1.32 =0.9090 C < C. Using his formula even if we add C to C it leads to C. What a magical Formula.

21. Consequence of Cascading two NOT gates.

Solution: It Simply forms a Buffer; used for Impedance Match or to Avoid any Loading Issue.

22. TIR & Critical Angle.

Solution: Whenever Light Ray enters from Denser to Rarer Medium, it partially gets Reflected & partially get Refracted until the Angle of Incidence reaches Critical Angle (angle of Incidence for whom Angle of Refraction is 90^o. If the angle of Incidence is more than the Critical Angle no Refraction occurs & the whole light Reflects back to the Denser Medium, this is Known as TIR (Total Internal Reflection)

23. Latent Heat; Melting Point & Boiling Point:

Solution: One of the Best Parameters in the Nature are the Melting Point of Solid & Boiling Point of a Liquid. Once you heat any Liquid, more you heat more temperatures it attains, however once it reaches to certain temperature it does NOT show any Rise in temperature, though the heat is still supplied. The Heat Now supplied is called Latent Heat (Hidden Heat) because it does NOT show any Rise in the thermometer & the fixed temperature is called Boiling Point of the Liquid. The whole heat is used to Convert Liquid into Vapours and it happens at a Constant Temperature called as BP of the liquid. Similar is the concept of MP of Solid.

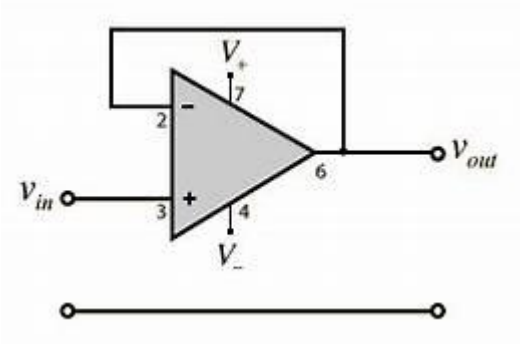
24. Significance of $E=mc^2$:

Solution: Actually, it is $E \propto m$. We know Mass & Energy are Interconvertible. If One Gram of Uranium is Converted into Energy, the Energy Released is $1x10^{-3} \times (3x10^8)^2 = 9x10^{13}$ Joules. It's a huge Amount of Energy.

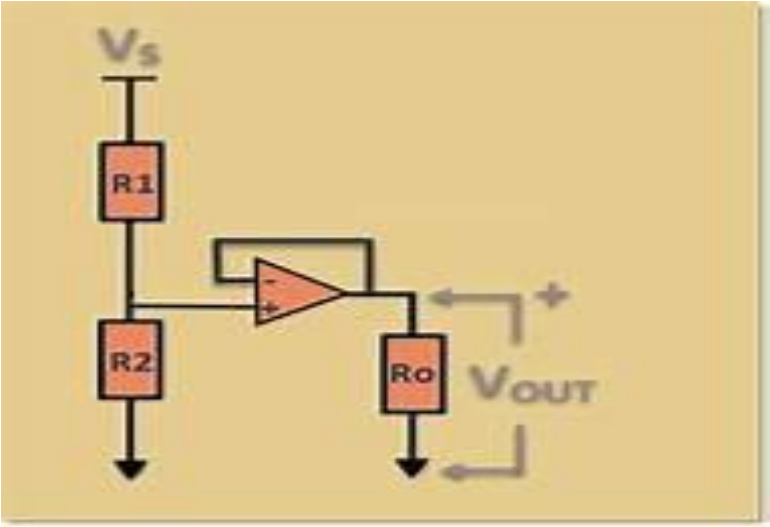
One of the best Example of Energy-Mass relation is Binding Energy of the Nucleus, when Nucleons combine to form the Nucleus, it is observed that there is a Mass Defect, Δm (=Mass of Nucleons before Combining – Mass of

Nucleus after Combining) & E = ΔmC^2, is the Amount of Energy Released when formation of Nucleus takes place and same Amount of Energy is required to break the Nucleus into it's Constituent Nucleons. Moreover 1 amu = 931MeV. Nuclear Bomb, is the Negative side of this Important Formula & Nuclear Energy Plant meant to Generate Electricity is the Positive side of the Formula, contributed by Einstein.

25. Op-Amp; Voltage Follower: An Interesting Configuration.



<u>Solution</u>: Simplest Configuration of Op-Amp as Voltage Follower. It is assumed that the dual Supply to the Op-Amp is ± 15 Volts. Now if Vin = 4 Volts, since Inverting follows Non-Inverting the Voltage at PIN 2 is also 4 Volts and since there is NO Resistance between PIN 2 & PIN 6 same Voltage will reach at PIN 6, implies Output is same as Input, hence the name Voltage Follower, also named as Buffer. However, there is a small difference in the Potential @ PIN 3 & PIN 2. How to measure that? Now ground PIN 3, implies Voltage at PIN 2 & PIN 6 has to be ZERO. Ideally Yes, but in most of the cases PIN 6 shows some small Voltage of the order of milli volts or some time microvolts. This Voltage is Exactly as ZERO Error in MSG & VC. It can be Positive or Negative & different Op-Amps has got different techniques to NULLIFY the same, before using the Op-Amp in any Circuit. Usually Nullification becomes Necessary when we are Interested in Accurate Results or when we are dealing with very small Voltages.



In the above Configuration assume Op-Amp is NOT there and the Load in directly connected to PDA (Potential Divider Arrangement). Let Vs = 15V & R_1 =R_2 = 10 KΩ. As per the Concept of PDA the Voltage at the Junction will be 7.5V, expected same Voltage it should provide to any Load connected across R_2.

Further let's assume that, R_O the Load is also 10KΩ. Now the Equivalent of R_2 & R_O is 5KΩ, the Voltage across R_O will reduce to 5V as per the concept of PDA. This is a Frequent Issue in Electronic Circuits and is defined as Loading Problem. However, with the Introduction of Op-Amp as Voltage Follower, this issue is Resolved. What does the Op-Amp do is Impedance match?

26. XRA, A; an Interesting Operation; Preferred to MVI A, 00.

<u>Solution</u>: We are Well Aware that XOR of two Similar Bits is ZERO, 0 XOR 0 = 0 & 1 XOR 1 = 0, Implies, even 8-Bit Data if XORed with it self will lead to ZERO. 3F XOR 3F = $(00000000)_2$ = $(00)_{16}$; Implies that, if you Need to make the Content of Accumulator ZERO the best way is XRA, A (One Byte) Rather than MVI A, 00; (Two Bytes).

27. Change in A & Z after Emission of α, β & γ Particle.

<u>Solution:</u> Change in A & Z after Emission of α, β & γ Particles

With α Emission, A Decreases by 4 & Z Decreases by 2.

With β Emission, A Remains Unchanged & Z Increases by 1.

With γ Emission, A & Z does NOT Change but the Daughter Nuclei are more Stable than the Parent Nuclei.

For Example a Radioactive Substance; $_{Z}X^{A}$ emits 8α, 8β & 8γ Particles, than the new A′ & Z′ are: A′ = A - 32, Z′= Z -16 + 8; Z′ = Z- 8; $_{Z'}Y^{A'} = {}_{Z-8}Y^{A-32}$

28. T.E of Electron in a H-Atom; If P.E = 2 K.E

Solution: Calculations Reveals that T.E of Electron in a H-Atom = -13.6 eV; P.E of the Electron is -27.2 eV & K.E of the Electron is = +13.6eV. T.E is Negative, means Electron is Bound to the Nucleus & can be made free by supplying Energy Equal to or more than 13.6 eV.

29. Number System & Equivalence: H, O & B.

Solution: Let's Consider any Arbitrary Number 7310 as $(7310)_8$ & $(7310)_{16}$.

Now the Binary Equivalent of 7 = 111, 3 =11, 2 =10 & 0 = 0 BUT

$(7310)_8 \neq (111\ 11\ 10\ 0)_2$ rather it is equal to $(111011010000)_2$

Similarly, $(7310)_{16} = (0111001100100000)_2$…… Understood!!!!!

30. Sum of two Numbers in HEX & FLAG Status.

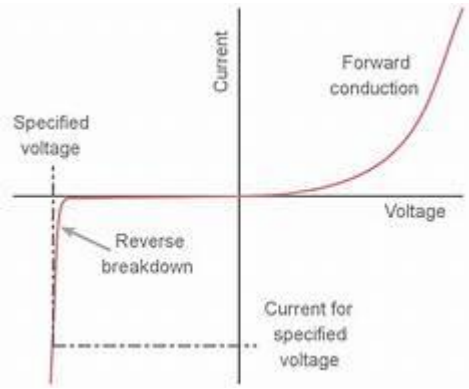
Solution: Let's Understand FLAG status of 8085 through an Example.

4C + D7 = 1 23 ; 1 23 = 1 0010 0011

S	Z	X	A	X	P	X	C
0	0		1		0		1

31. Zener a Voltage Regulator:

Solution:



Refer the Diagram above, Specifically the Reverse Characteristics of the Zener; At Breakdown the Voltage is FIXED & Current can Vary from any Lower value to any Higher value, Simply Current is Adjustable!!!

Now let's consider the Zener in the Circuit below & as an Example, let the Breakdown Voltage of the Zener is Approx. 6 Volts. Now Role of ZENER is to maintain the Voltage Across the Load fixed, even if Load Value Changes or the Input Voltage Fluctuates. Let's Understand with Different cases:

a) Input Voltage is FIXED that is 10 Volts. The Zener as per his Nature will take 6Volts & Remaining Left Over, i.e 4 Volts will drop Across the Resistor R_S. Now let $R_L \uparrow$ so $I_L \downarrow$, to keep V_L, constant [as $V_L = I_L \times R_L$,] in this case the Excess Current will flow through Zener as I_Z, since the Current through Zener is adjustable at Breakdown Voltage. Now let $R_L \downarrow$ so $I_L \uparrow$, to keep V_L, constant [as $V_L = I_L \times R_L$,], in this case the Lesser Current will flow through Zener as I_Z, since the Current through Zener is Adjustable at

Breakdown Voltage. In any case Voltage Remains Constant.

b) Let Input Voltage Fluctuates and ↑ to 12 Volts, as per the Characteristic of the Zener it will take 6 Volts only & Remaining 6

Volts will drop Across R_S, since R_L is parallel to Zener will also enjoy same constant 6 Volts. In this process if any ↓ or ↑ of current happens will be taken care as in case a).

c) **Let Input Voltage Fluctuates and ↓ to 8 Volts, as per the Characteristic of the Zener it will take 6 Volts Only & Remaining 2 Volts will drop across R_S, since R_L is parallel to Zener will also enjoy same constant 6 Volts. In this process if any ↓or ↑ of current happens will be taken care as in case a).**

d) **Case "a" comes under Load Regulation & "b" & "c" comes under Line Regulation.**