Paper 4

9702

Frequently asked questions

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. Circular Motion:

- **Radians:**
  Angle Subtended at the center of the circle when the arc length is equal to the radius of the circle.

- **Angular Speed:**
  Angle swept out per unit time.

. Gravitational Fields:

- **Gravitational Field Strength:**
  It is a force on unit mass in a gravitational field.

- **Gravitational Field:**
  It is a space or region around a mass where another mass experiences force of attraction or gravitational pull.

- **Field of force:**
  It is a region where a particle experiences a force.

- **Gravitational Force**
  It is the force acting between 2 masses/It is the force on mass due to another mass/ It is the force on mass in a gravitational field.

- **What is meant by line of gravitational force:**
  It is the direction of force on a mass/ It is a path in which a mass will move.

- **State Newton's law of gravitation**
  Force is proportional to the product of the 2 point masses and inversely proportional to the square of their separation

- **Gravitational Potential**
  Work done in moving a unit mass from infinity to that point.

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- **Why Gravitational Potential is negative.**
  Gravitational force is attractive, so when the body comes near the surface from infinity, the work goes out.

- **Explain why the gravitational field strength g close to Earth's surface is approximately constant (3 marks)**
  At the surface, lines of force are radial. Earth has a large radius (height above surface is small) so this means that lines are parallel. Since lines are parallel there is a constant field strength.

- **Why it may be assumed that the Sun is isolated in space from other stars.**
  A force would have little effect on large mass of the Sun. This would cause a negligible acceleration of the Sun of
  $1.0 \times 10^{-14}\, ms^{-2}$

- **Why the energy required to launch the satellite depends on whether the satellite, in its orbit, is travelling from west to east or from east to west.**
  Any one point from:
  - Smaller gain in energy required if orbit is west to east.
  - Smaller change in velocity if orbit is west to east.
  - Smaller gain in energy if orbit is in the same direction as Earth's rotation.
  - Smaller change in velocity if orbit is in the same direction as Earth's rotation.
  - Satellite already moving west to east at launch.
  - Earth's rotation is from west to east.

- **How to decide if a point is nearer or far from planet.**
  The point closer to planet will be more negative.

- **What is weightlessness?**
  Weight or sensation of weight or the reaction force is the difference between gravitational force and centripetal force. If this difference is zero, we feel weightlessness.

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- **Geostationary satellite**
  They orbit above equator.
  Move from west to east, same direction as spin of earth.
  Time period is 24 hours.

- **Show that Kinetic energy of the satellite is given by this expression:**

$$\boldsymbol{E_K = \frac{GMm_s}{2x}}$$

$$F_C = F_G \quad \frac{GMm_s}{x^2} = \frac{m_s v^2}{x}$$

$$v^2 = \frac{GM}{x}$$

$$KE = \frac{1}{2}mv^2$$

$$\frac{1}{2}m_s\left[\frac{GM}{x}\right] = \frac{GMm_s}{2x}$$

. Temperature:

- **Explain structure of Solid, Liquid and Gas**
  Solid:
  Closely packed, regularly arranged at fixed positions.
  Liquid:
  Loosely packed and in clusters
  Gas:
  Randomly moving with large intermolecular spaces

- **Specific Latent Heat**
  Amount of energy required to change the state of a body of unit mass at constant temperature.

- **Why melting and boiling takes place without the change in temperature**
  Energy is used to break the bonds of attraction and increase amplitude of motion.

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- **Why latent heat of vaporization is higher than the specific latent heat of fusion.**
  In liquids, the bonds of attraction are not completely broken but in gas the bonds are completely broken and for that more energy is required.

- **Why thermometers record different temperature.**
  Temperature scale is calibrated assuming linear change of property with temperature, but thermometric properties do not vary linearly with temperature.

- **Absolute scale of temperature does not depend on property of substance.**

- **Absolute zero**
  Temperature at which atoms have zero energy.

- **Thermal Equilibrium**
  There is no net transfer of thermal energy between two bodies i.e., they are at the same temperature.

- **Why the liquid in glass thermometer does not provide the direct measurement of thermodynamic temperature**
  This thermometer depends in the properties of real substance and 0C is not absolute zero

. Ideal Gases:

- **Basic assumptions of Kinetic theory**
  - Consists of atoms or molecules that behave as hard, identical spheres that are in continuous motion and undergo elastic collisions.
  - Time of collisions is negligible in comparison to time between collisions.
  - No intermolecular forces
  - Random motion of molecules
  - Large numbers of molecules
  - Volume of atom is negligible as compared to volume of container.

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- **Ideal Gases**
  Gases which obey PV=nRT

- **State what is meant by an elastic collision.**
  No loss of kinetic energy

- **Use the first law of thermodynamic to explain why the external work w done on the gas during expansion is equal to the increase in internal energy.**

$$\boldsymbol{\Delta U = Q + W}$$
$$\mathbf{Q = 0 \text{ so } \Delta U = W}$$

- **When gas expands, what happens to the temperature of the gas (3 marks)**
  When gas expands, the speed of molecule decreases. Mean square speed is directly proportional to thermodynamic temperature. Kinetic energy of molecules decreases so temperature decreases and vice versa.

. Thermodynamics:

- **Specific heat capacity**
  Energy required to raise temperature of a body of mass 1kg through 1º C.

- **First law of Thermodynamics**
  U= Q+W

- **Internal Energy**
  Sum of randomly distributed kinetic and potential energy of molecules.

- **Avogadro constant**
  The number of atoms in 12g of Carbon 12 (6.02×10^{23})

- **What is meant by a mole?**
  Amount of substance containing particles as mass of .012 kg of Carbon 12

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- **Meaning of $< C^2 >$**
  Mean of square of speeds of atoms

- **Why temp changes during compression**
  When Q is zero, work done is used to increase internal energy as internal energy increases so the kinetic energy and so the temperature increases.

- **State and explain the total change, if any, in the internal energy of the gas during one complete cycle**
  There is no change in internal energy, so gas returns to its original temperature.

- **By reference to the first law of thermodynamics, state and explain the change, if any, in the internal energy of**
  - A lump of solid lead as it melts at constant temperature.
    There are little/no volume changes so little/no external work done. Thermal energy is supplied to provide latent heat so internal energy increases.

  - Some gas in a toy balloon when the balloon bursts and no thermal energy enters or leaves the gas.
    There is a rapid increase in volume. Gas does work against the atmosphere so internal energy decreases.

- **By reference to intermolecular forces, explain why the change in internal energy of an ideal gas is equal to the change in total kinetic energy of molecules.**
  In ideal gases there are no intermolecular forces so there is no potential energy so change in kinetic energy is change in internal energy

- **How gases exert pressure**
  Gas particles are in random motion, so they collide with walls of vessel and during collision there is change of momentum. Rate of change of momentum is force and force per unit area is pressure.

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. Oscillations:

- **Amplitude**
  Maximum displacement from mean position

- **Time period**
  Time taken by one complete oscillation.

- **Frequency**
  Number of oscillations passing through a point in unit time

- **Angular frequency**
  Angle swept per unit time by and object.

- $a = -w^2x$ **State the significance of the (-) negative sign in this equation.**
  Acceleration and displacement are in opposite directions.

- **Simple harmonic motion**
  Free oscillation in which acceleration is directly proportional to displacement and is directed toward mean position.

- **State 2 conditions necessary for a mass to be undergoing simple harmonic motion.**
  1. Acceleration proportional to displacement
  2. Acceleration and displacement are in opposite directions.

- **Forced oscillation.**
  In which there is some external force acting on the body to make it oscillate

- **Free oscillation**
  The natural oscillation of the body under the influence of no external force. Amplitude is constant.

- **What is meant by damping?**
  Decrease in energy and amplitude due to friction

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- **Resonance**
  Increase in the amplitude of motion when the frequency of external force matches with natural frequency.

- **When is resonance useful?**
  During ultrasound
  Due to vibration of quartz crystal amplitude of ultrasound waves is maximized.

- **When is resonance avoided?**
  During vibration of metal panels. Either change shape and area of panels or place strengthening struts to avoid it

Electric Field:

- **Electric field strength**
  The electrostatic force experienced per unit positive test charge.

- **Electric potential**
  The work done per unit positive test charge in moving it from infinity to that point in the field.

- **Compare electric and gravitational field.**
  Similarity: They are both radial field lines
  Difference: Gravitational field is always towards the mass. Electric field can be towards or away from the charge.

- **State the relationship between electric potential and electric field strength at a point.**
  Field strength = negative potential gradient/The electric field due to a point charge is negative potential gradient due to the point charge

- **By reference to electric field lines, explain why for points outside an isolated spherical conductor for the charge on the sphere may be considered to act as a point charge as its center.**
  The lines are radial. The lines appear to come from the center.

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- **State Coulomb's law**
  Electric force between 2-point charges is directly proportional to the product of charges and inversely proportional to the square of the distance between them from their centers.

. Capacitance:

- **Capacitance**
  The ratio between the charges on one of the plates of the capacitor and the potential difference applied across the plates.

- **Farad**
  The capacitance of a capacitor is 1 farad if a 1-coulomb charge is stored by 1-volt voltage.

- **Uses of capacitor**

- For smoothing ripples in alternating current
- As time delay circuit
- To store energy
- Tuning
- Oscillator
- Blocking d.c
- Surge protection

- **Suggest why when the capacitor is connected across the terminals of a battery the capacitor stores energy not charge.**
  Equal and opposite charges on the plates so no resultant charge. Positive and negative charges are separated so energy stored.

. Magnetic field:

- **Magnetic field**

Space of region where a magnet/ magnetic material/ moving charge/ current carrying conductor experiences a force.

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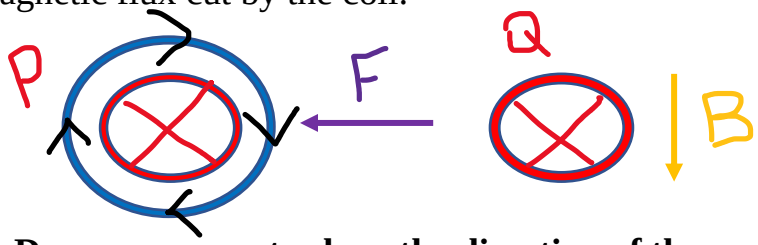
- **Magnetic flux density**
  Force experienced per unit length conductor carrying unit ampere current placed perpendicularly inside the magnetic field.

- **Tesla**
  Magnetic flux density is 1 tesla if 1-newton force is experienced per unit length conductor carrying unit ampere current placed perpendicularly inside the magnetic field.

- **Magnetic flux**
  Number of field lines passing through unit area

- **Magnetic flux linkage**
  Magnetic flux cut by the coil.

- 

  - **Draw an arrow to show the direction of the magnetic field at wire Q due to the current in wire P. Label this arrow B.**
  - **Draw another arrow to show the direction of the force acting on wire Q due to the current in wire P. Label this arrow F.**

  - **State, with a reason, how the magnitude of the force acting on wire P compares with the magnitude of the force on wire Q.**
    Force is proportional to product of both currents.
  - **State how the direction of the force on wire P compares with the direction of the force acting on wire Q.**
    Opposite

  - **State two situations in which a charged particle in a magnetic field does not experience a force.**
    1. Particle is stationary.
    2. Particle is moving parallel to the magnetic field.

- **Explain why the electrons follow a circular path when inside the region of the magnetic field (3 marks)**
  The force is always perpendicular to the velocity and the magnetic force provides the centripetal force, so the magnitude of the force is constant.

- **Explain how a uniform magnetic field in a uniform electric field may be used as a velocity selector for charged particles (3 marks)**
  Electric and magnetic fields are at right angles to one another. Particles may enter the fields with velocity normal to the two fields so there is no deviation for particles with selected velocity.

- **State and explain the effect, if any, on the polarity of the hall voltage when negative charge carriers are replaced with positive charge carriers, moving in the same direction towards the slice.**
  The negative and positive charged carriers would deflect in opposite direction so there is no change in polarity.

- **Explain how the steady Hall voltage is developed between the 2 faces**
  Force on charge carriers is perpendicular to both magnetic field and current as charge carriers are deflected to one side, an electric field is set up. Electric and magnetic forces on charge carriers are equal and opposite

- **Explain why a hall probe is made from a thin slice of material.**
  Hall voltage depends on the thickness of the slice. The thinner the slice the larger the hall voltage

- **Explain why for consistent measurements of magnetic flux density to be made the current in the probe must be constant.**
  Hall voltage depends on the current and in the slice.

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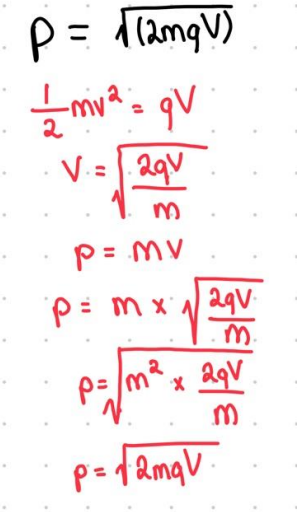
- **Show that the magnitude *p* of the momentum of the electron as it enters the magnetic field is given by.**



. Electromagnetic induction:

- **State Faraday's law of electromagnetic induction**
  The magnitude of the induced EMF is directly proportional to the rate of change of magnetic flux linkage.

- **State Lenz's law of electromagnetic induction**
  It is the direction of induced EMF is opposite to the source producing it.

. Alternating current:

- **State by reference to the power dissipated in a resistor, what is meant by the root-mean-square (r.m.s.) value of an alternating voltage.**
  It is the voltage of dc supply which gives the same power supply as the alternating voltage.

- **State and explain, with reference to the principles of electromagnetic induction, the effect of the increased speed of rotation on the r.m.s. value of the induced E.M.F.**
  The rate of cutting magnetic flux doubles hence r.m.s. is induced and EMF is doubled.

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- **By reference to heating effect explain what is meant by root mean square value (r.m.s.) of an alternating current**
  It is the direct current that produces the same heating effect as the alternating current.

- **The mean value of an alternating current is zero. Explain why heating occurs when there is an alternating current in a resistor.**
  A.C. changes direction every half cycle but heating effect is independent of current direction.

- **Transmission of electrical energy is frequently achieved using alternating high voltages.**
  - **Suggest why high voltages are used.**
    For the same power there is a lower current. Lower current means there is less power loss in cables.

  - **Suggest why the voltage is alternating.**
    Any 2 from:
    - ♦ Voltage can be easily stepped up/down.
    - ♦ Transformers only work with a.c.
    - ♦ Generators produce a.c.
    - ♦ Easier to rectify than invert.

- **A capacitor with a large capacitance is connected across the terminals of the supply. Suggest and explain why this may lead to a large current from the supply.**
  A large amount of charge is required to charge the capacitor. The capacitor would charge and discharge rapidly.

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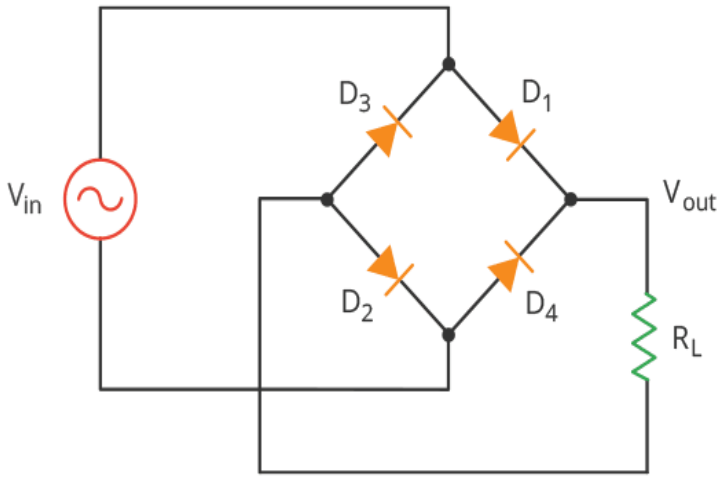
- **Draw 4 diodes for full-wave rectification (Wheat stone bridge)**



- **Explain what is meant by smoothing.**
  Reduction in the variation of the output voltage/current

- **State the effect of the value of the capacitance of the smoothing capacitor in relation to smoothing.**
  Larger capacitance produces more smoothing for the same load.

- **Suggest one advantage of the use of a bridge rectifier, rather than a single diode, for the rectification of alternating current.**
  Power is supplied on every half-cycle.

. Quantum physics:

- **State what is meant by the photoelectric effect**
  The emission of electrons when electromagnetic radiation is incident

- **Work function energy**
  Minimum energy required by any electron to be ejected from the metal surface

- **Threshold frequency**
  If the energy of incident photon is exactly equal to the work-function energy, then the frequency of photon is called threshold frequency

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- **State what is meant by a photon**
  It is a quantum of energy of electromagnetic radiation. Simply known as packet of energy.

- **Explain why the maximum kinetic energy of the electron is independent of the intensity of the incident radiation**
  Frequency determines energy of photon. Intensity determines number of photons per unit time not energy of a photon. Kinetic energy of the electron depends on the energy of one photon

- **State the observations associated with the photoelectric emission that provide evidence for a particulate nature of electromagnetic induction**
  1. Minimum frequency of electromagnetic radiation below which emission of electrons does not occur
  2. Maximum kinetic energy of electrons is independent of intensity
  3. Maximum kinetic energy of electrons depends on frequency
  4. No time delay between illumination and emission

- **State an experimental phenomenon that provides evidence for the particulate nature of electromagnetic radiation.**
  Photoelectric effect

- **State an experimental phenomenon that provides evidence for the wave nature of matter.**
  Electron diffraction

- **In $\lambda = h/p$ h is the plank's constant**

- **Define gravitational potential at a point**
  It is the work done per unit mass. Work done moving mass from infinity to the point

- **Explain why the gravitational potential near the isolated mass is always negative**
  Gravitational force is attractive. Gravitational potential at infinity is zero. There is a decrease in potential energy as masses approach.

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- **State what is meant by de Broglie wavelength**
  Particle/electron has a wavelength associated with it dependent on its momentum.

- **State what is meant by the hardness of an X-ray beam**
  It is the penetration of beam. Greater hardness means greater penetration

- **How can we control hardness of X-ray beam**
  To increase hardness, increase the potential difference between the anode and cathode

- **The spectrum of the light emerging from the cloud of cool gas is viewed using a diffraction grating. Explain why this spectrum contains a number of dark lines.**
  Electrons interact with photons. Photon energy causes electron to move to higher energy level/to be excited. Photon energy = difference in energy of electron energy levels. When electrons de-excite, photons are emitted in all so directions so there is a dark line.

- **Explain how the emission spectrum from hydrogen gas provides evidence for the existence of discrete energy levels for the electrons in hydrogen atoms**
  - Energy of photon has a corresponding frequency
  - Change in electron energy level emits a single photon
  - Photon energy = difference in energy levels
  - Discrete frequencies must have come from discrete energy gaps
  - Discrete energy changes imply discrete energy levels

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. Nuclear physics:

- **Mass defect**
  It is the difference between mass of the nucleus and mass of its component nucleons when the nucleons were separated into infinity completely.

- **Binding energy**
  Energy required by a nucleus to split itself into individual nucleons completely to send them into infinity

- **Nuclear fusion**
  Combining of 2 lighter nuclei to make heavier nucleus with loss in mass that is converted into energy

- **Nuclear fission**
  Splitting of heavier nucleus into 2 lighter nuclei with loss in mass that is converted into energy

- **Spontaneous decay**
  It does not depend on any surrounding external factors

- **Random nuclear decay**
  No one can predict which nucleus will decay, how many radiations will be emitted, the time of emission and direction of emitted radiation

- **Activity**
  The number of radioactive nuclei decreasing per unit time

- **Decay constant**
  The probability of any nucleus to decay per unit time is called decay constant

- **Half life**
  The time taken for the number of parent nuclei to decrease to half their original number

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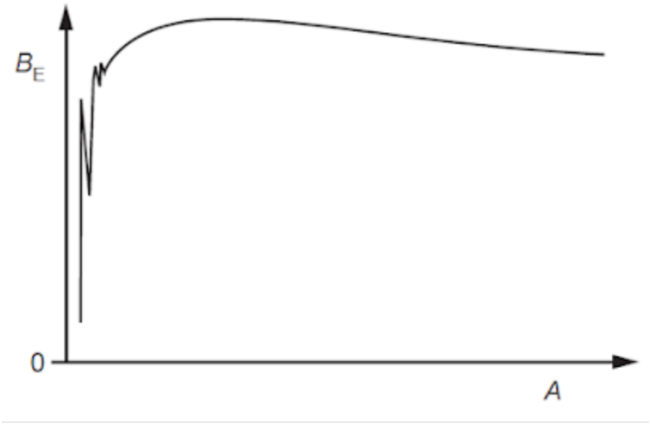
- **Sketch variations of binding energy per nuclear with nucleon no.**



- **Explain what is meant by gamma radiation**
  Photons of electromagnetic radiation emitted from nuclei

- **State what is meant by isotopes**
  Nuclei having same number of protons with different numbers of neutrons

- **State 3 reasons why the activity of the sample is not equal to the measured count rate**
  1. Background radiation
  2. Multiple possible counts from each decay
  3. Radiation emitted in all directions
  4. Dead time of counter
  5. Product unstable/also emits radiation
  6. Self-absorption of radiation in sample

- **Distinguish for an atom between a nucleus and a nucleon.**
  Nucleus: Small central part of an atom
  Nucleon: proton or a neutron. Particle contained within a nucleus

- **Show that the energy from the mass 1 unit is 934 MeV**

$$E = mc^2$$
$$E = 1.66 \times 10^{-27} \times (3 \times 10^8)^2$$
$$E = \frac{1.49 \times 10^{10}}{1.6 \times 10^{-13}}$$
$$E = 934\ MeV$$

. Medical physics:

- **Give principles of generation of ultrasonic waves**
  A piezo electric crystal is coated with silver on opposite faces. These act like electrodes.
  Centers of +ve and –ve charge are not coincident.
  Crystal changes shape due to this potential difference
  When an alternating voltage of ultrasound range is applied across crystal, the crystal oscillates
  Crystal is cut to produce resonance and vibrates at resonant frequency.

- **Give principles of generation and detection of ultrasonic waves**
  A piezo electric crystal is coated with silver on opposite faces. These act like electrodes.
  Crystal changes shape due to potential difference
  Centers of +ve and –ve charge are not coincident due to potential difference.
  When an alternating voltage of ultrasound range is applied across crystal, the crystal oscillates
  Crystal is cut to produce resonance and vibrates at resonant frequency.
  When wave is reflected back it causes crystal to vibrate
  Alternating voltage is produced across the crystal.

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- **Give principles behind the use of ultrasound**
  Pulse of ultrasound is sent
  The pulse reflects at boundary
  Reflected pulse is detected by transducer
  Detected signal is processed and displayed.
  Time taken by pulse during transmission and reception is gives depth of boundary.
  Intensity of reflected pulse gives information about nature of boundary.

- **Effect of large difference between acoustic impedances of two media.**
  Transmitted intensity will be small and reflected intensity will be equal to incident intensity.

- **Give meaning of specific acoustic independence**
  Product of density and speed of wave in that medium.

- **Why to use gel**
  There is very little transmission of wave at air skin boundary and majority of wave is reflected. Gel ensures almost complete transmission.

- **Importance of using high frequency ultrasound as compared to low frequency ultrasound.**
  Better resolution at shorter wavelength so smaller structures can be distinguished

- **Why the ultrasound from the transducer is pulsed.**
  Transducer is also used as receiver. It receives pulses between emitted pulses to determine depth and nature of boundaries.

- **State what is meant by the attenuation of an ultrasound wave**
  It is the reduction in the intensity of a wave as the wave passes through the medium

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- **State how these differences affect the intensity reflection coefficient at the boundary between the 2 media**
  - $\boldsymbol{Z_1 \approx Z_2}$**:** Coefficient very small/nearly 0
  - $\boldsymbol{Z_1 \gg Z_2}$ $\boldsymbol{or}$ $\boldsymbol{Z_1 \ll Z_2}$**:** Coefficient nearly 1

- **Sharpness of X-ray**
  How well defined the edges of organs are. A parallel x-ray beam is required, which can be done by reducing area of target anode, reducing size of window, and use of metal blockage to get collimated beam.

- **Contrast of X-ray**
  The degree of blackening of the image of organ as compared to neighboring tissues. It depends on absorption of X-rays

- **State how can we control the intensity and hardness of the X-ray beam**
  Intensity: Vary p.d. across filament
  Hardness: Vary accelerating potential difference

- **Explain why a continuous spectrum of energies of X-ray photons are produced**
  Electrons decelerate so X-ray photons produced. There are ranges of decelerations. Photon energy depends on magnitude of decelerations.

- **Explain why at certain wavelengths, there are narrow peaks of increased intensity**
  Electron in the inner shell of target atom is excited on collision. Electron de-excites causing emission of a photon. There are discrete energy levels so discrete photon wavelengths

- **Explain why there is a sharp cut-off at short wavelength**
  Electron gives all its energy to one photon. Electron stopped in single collision

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- **State how are longer wavelength photons filtered and why**
  They are filtered by an aluminum sheet/filter/foil placed in beam from tube. This is done so the long wavelength X-rays do not pass through the body

- **Outline the principles of CT scanning**
  X-rays are used to scan in sections from many angles. Image of each section is 2-dimensional. The images are combined to form a 3-dimensional image of a structure

- **State the purpose of CT scanning**
  To produce a 3-dimensional image of a structure

- **Suggest why CT scanning was not possible before fast computers with large memories were available**
  Combining images involves very large number of calculations

- **Suggest why the radiation dose for a CT scan is much larger than for an X-ray image of a leg bone**
  CT scan consists of many single X-ray images

- **What is a PET scanner**
  A PET scanner is a ring of gamma cameras placed around the patient so that an accurate 3D image can be generated from the emission site of the gamma photons. Photons strike detectors exactly opposite and a line of response can be drawn

- **Positrons are not naturally present in the body so how is it present during PET scan**
  Positrons are emitted from the tracer which is introduced to the body

- **How do positrons cause the emission of gamma radiations during PET scan**
  The positron emitted from the tracer interacts with the electron in our body immediately. Annihilation occurs between the positron and electron and the mass of the particles is converted into gamma photon

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- **What is a tracer**
  A tracer should be radioactive. They should have a small half-life so that our body does not remain in radiations for a long time. They should be easily absorbed by the human body. For humans the tracer should be water and glucose as they can easily be absorbed

- **What is meant by annihilation**
  A particle interacting with its antiparticle so that mass is converted into energy

- **Explain how gamma photons are used to produce an image**
  - The 2 gamma photons travel in opposite directions
  - Gamma photons detected outside the body by detectors
  - Gamma photons arrive at detector at different times
  - Determine location of production of gamma
  - Image of tracer concentration in tissue produced

. Astronomy and cosmology:

- **What is meant by luminosity of a star**
  Total radiant power

- **State Wien's displacement law**
  Wavelength of maximum intensity is inversely proportional to thermodynamic temperature

- **State what is meant by a redshift**
  Apparent increase in the wavelength due to the movement of star away from the observer

- **Explain how cosmologists can determine that light from a distant star has undergone redshift**
  By examining and comparing the know spectrum with the spectrum with the star

- **State Hubble's law**

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The further the receding the star is the higher the velocity

- **State Stefan Boltzmann law**
  The luminosity of a star is a function of both its radius and its surface temperature

- **What is meant by standard candle**
  An astronomical object which has a known luminosity due to a characteristic quality possessed by that class of the object

- **Explain how the surface temperature of a distant star may be determined from the wavelength spectrum of the light from the star**
  Wavelength of peak intensity is determined from the spectrum of the star. The wavelength of peak intensity from object of known temperature determined. Wien's displacement law is used in which wavelength of peak intensity is inversely proportional to temperature

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