I. Gravitational field

field strength

1. Define *gravitational field strength*.

   force per unit mass

2. By reference to the pattern of the lines of gravitational force near to the surface of the Earth, explain why the acceleration of free fall near to the Earth's surface is approximately constant.

   . the lines are radial

   . radius of Earth is much larger than the change in height

   . so near the surface the lines are approximately parallel

   parallel lines so constant field strength

   . constant field strength hence constant acceleration of free fall

3. State what is meant by a *line of gravitational force*.

   direction of force on a mass

4. Explain how a satellite may be in a circular orbit around a planet

gravitational force provides centripetal force about the planet

5. State what is meant by a *gravitational force*.

   force acting between two masses

6. Suggest why the total force between the spheres may not be equal to the force calculated using Newton's law of gravitation.

   . spheres are not point masses

   . spheres may not be uniform

7. state what is meant by a *field of force*.

   region of space where a particle experiences a force

8. State Newton's law of gravitation.

   gravitational force between two point masses is proportional to product of masses and inversely proportional to square of separation

gravitational potential

1. Suggest why, for small changes in height near the Earth's surface, gravitational potential is approximately constant.

. change in height is much smaller than radius near Earth's surface

. potential is inversely proportional to radius and radius is approximately constant so potential is approximately constant

2. Define *gravitational potential* at a point.

. work done per unit mass

. in moving mass from infinity to the point

3. why the gravitational potential near an isolated mass is always negative.

. force is attractive

. potential at infinity is zero

. decrease in potential energy as masses approach and displacement and force in opposite directions

II. Oscillation

1. Explain what is meant by the *natural frequency of vibration* of a system.

frequency at which body will vibrate when there is no external resistive force acting on it

2. Explain how it can be deduced from the expression that the block moves with simple harmonic motion. （a = -k/m x ）

. defining equation of s.h.m. is a = –Kx where K is a constant

. k and m are constant so k/m is constant so acceleration is proportional to displacement

. negative sign shows that acceleration is in opposite direction to displacement

3. Use energy conservation to explain why the energy of the oscillations decreases more rapidly than in **(d)**（一边振动一遍切割磁感线）

. flux of the block changes which induces an e.m.f. in block

. currents induced causes thermal energy dissipated in block

. thermal energy comes from energy of oscillations of the block

4. Use Fig. 2.2(图像) to show how it can be deduced that the sand is undergoing simple harmonic motion.

. straight line (through origin) indicates acceleration is proportional to displacement (from equilibrium position)

(如果过原点加（1），不过原点加（2））

. negative gradient shows acceleration and displacement are in opposite directions

5. why this is light damping

   amplitude decreases gradually so light damping

6. State, by reference to simple harmonic motion, what is meant by *angular frequency*.

   angular frequency is equal to 2π × frequency

7. Define the *radian*.

   angle subtended at the centre of a circle by an arc of length equal to the radius of the circle.

8. State what is meant by the *displacement* of the mass on the spring.

   distance from a reference point in a given direction

III. Medical imaging

ultrasound

1. Explain the main principles behind the **use** of ultrasound to obtain diagnostic information about internal body structures.

. pulses of ultrasound produced by piezo-electric crystal, such as quartz crystal,

. reflected at boundaries between media

. reflected pulses detected by ultrasound generator

. reflected signal processed and displayed

Any three from:

. time delay between emission and detection gives information about depth of boundary

. intensity of reflected pulse gives information about nature of boundary

. gel used to minimize reflection at skin

. degree of reflection depends upon impedances of two media at boundary

2. Explain the main principles of the **generation** of ultrasound waves for medical use.

. piezo-electric crystal, such as quartz crystal, is used

. p.d. across crystal can cause it to distort

. alternating p.d. applied across crystal / transducer

-causes crystal to vibrate

. when applied frequency is natural frequency, crystal resonates

. natural frequency of crystal is in ultrasound range

3. Explain why ultrasound used in medical diagnosis is emitted in pulses.

. the reflected signal can be distinguished from the emitted signal

. detection occurs in the time between emitted pulses

. reflected ultrasound are detected by same crystal

. so it cannot emit and detect at same time

4. Explain the principles of the **detection** of ultrasound waves used in medical diagnosis.

. piezo-electric crystal, such as quartz crystal, is used

. reflected pulses of ultrasound is incident on the crystal,

. which makes the crystal vibrate and distort

. vibration produces alternating e.m.f. across the crystal

5. Suggest one advantage of the use of high-frequency ultrasound rather than lower-frequency ultrasound.

   small structures can be observed

6. Define *specific acoustic impedance*.

   . product of density and speed

   -of ultrasound in the medium

7. Discuss qualitatively how the relative magnitudes of the two specific acoustic（Z1，Z2） impedances affect the reflected intensity(the ratio α)

   (intensity reflection coefficient depends on difference between acoustic impedance, 看题目有没有说有关系)

   . Z_1 is approximately equal to Z_2 then there will （be negligible reflection）(ratio is close to 0)

   . If $Z_1 \gg Z_2$ or $Z_1 \ll Z_2$ then most ultrasound will （be reflected ）(ratio is close to 1)

   . $I_r / I_0 = (Z_A - Z_B)^2 / (Z_A + Z_B)^2$

8. Use your value in **(b)(i)** to explain why gel is applied to the surface of the skin during an ultrasound scan.

   . without the gel most of the ultrasound is reflected

. Z values of gel and skin are more similar, so reflection coefficient α reduces

. so less ultrasound is reflected at skin

9. State what is meant by *attenuation* of an ultrasound wave.

   loss of power and intensity as the wave passes through the medium

X-ray

1. Suggest **two** causes of lack of sharpness of an X-ray image.

   . anode area large

   . no lead grid and slits

   . aperture is large

   . lack of collimation of beam

2. what is meant by the *hardness* of an X-ray beam

   . penetration of beam

   . greater hardness means greater penetration and higher frequency

3. how the hardness of an X-ray beam from an X-ray tube is increased.

greater accelerating potential difference

4. State what is meant by the *contrast* of an X-ray image.

   . difference in degrees and amount of blackening

   -between structures

5. Describe the basic principles of CT scanning (computed tomography).

   . section of a patient is scanned using X-ray

   . many images of one section are taken at many angles

   . images of each section are 2-dimensional

   . this is repeated and images of many sections are combined by a computer to give a 3-dimensional image of whole structure

6. why CT scanning was not possible before fast computers with large memories were available

   combining of images involves very large number of calculations

7. 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

IV. Electricity

electric field

1. State what is meant by *electric potential* at a point.

   . work done per unit charge

   -in moving positive charge from infinity to the point

2. State what is meant by *electric field strength*.

   force per unit charge acting on positive charge

3. State Coulomb's law.

   electrical force between two point charges is proportional to product of charges and inversely proportional to the square of the separation

4. Use Fig. 6.2 to explain whether the two spheres have charges of the same, or opposite, sign. (E 图，E 从正变为负数)

   . the field at the point near A is in opposite direction to the field at the point near B

   . so field changes direction between A and B

   . so same sign of charge

5. For any point outside a spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre. By reference to electric field lines, explain this.

   electric field lines are radial so these lines appear to originate from centre of sphere

6. State the relationship between electric potential and electric field strength at a point.

   field strength = – potential gradient

7. why the magnitude of the electric field strength at P is given by the sum of the magnitudes of the field strengths due to each sphere

   fields due to each sphere are in same direction

8. why the electric field strength at point P due to the charged metal spheres is not, in practice, equal to 2*E*, where *E* is the electric field strength determined in **(b)**.

   . charges on spheres attract each other

   . charge distribution on each sphere is distorted by the other sphere

   . spheres are not point charges at their centers anymore

capacitor

1. Suggest why, when the capacitor is connected across the terminals of a battery, the capacitor stores energy, not charge.

   . equal and opposite charges on both plates so no resultant charge

   . positive and negative charges are separated so energy is stored

2. Define the *capacitance* of the capacitor.

   the ratio of charge on one plate to the potential difference between the plates

   (Capacitance= charge / potential difference which is charge per unit potential difference)

3. State two different functions of capacitors in electrical circuits.

   . it used in time delay circuit for timing

   . smoothing which is to reduce ripple of current

   . to block direct current

   . in oscillator circuits

V. Magnetic

magnetic field

1. Define the *tesla*.

   . newton per ampere

   . newton per meter

   . magnetic field is normal to current

2. Explain why a magnetic force is exerted on each wire. (两个同方向电流)

   current in each wire creates a magnetic field at the other wire and current is at 90° to field, which causes force

3. State what is meant by a *magnetic field*.

   a region where a moving charge and a current-carrying conductor experience a force

magnetic flux

1. Define *magnetic flux*.

   product of flux density and area. The direction of flux and flux density is normal to area

2. State what is meant by the *magnetic flux linkage* of a coil.

. magnetic flux density × area × number of turns on coil

-and magnetic flux density is normal to area

3. Define *magnetic flux density*

. force per unit current

. per unit length of wire

. current normal to magnetic field

4. State Faraday's law of electromagnetic induction.

induced e.m.f. is proportional to rate of change of magnetic flux linkage

5. Use Faraday's law and energy conservation to explain why the amplitude of the oscillations of the magnet reduces after the switch of the circuit is closed?

. coil cuts field, so the magnetic flux linkage of the coil changes which induces e.m.f. in coil

. induced current caused by the e.m.f.in resistor causes heating effect

. thermal energy comes from energy of oscillations

6. State Lenz's law.

direction of induced e.m.f. tends to oppose the change causing it

7. Use Lenz's law to state and explain the direction of the magnetic field due to the induced current in the small coil. (solenoid 在下，small coil 在上)

   . magnetic field in solenoid is increasing

   . field in coil in opposite direction to oppose increase

8. Use laws of electromagnetic induction to explain why, when the switch is closed, the current increases **gradually** to its maximum value.

   . increasing current causes increasing flux

   . increasing flux induces e.m.f. in coil

   . induced e.m.f. opposes growth of current

9. Use Faraday's law to explain why the output from the transformer is an electromotive force (e.m.f.) that is alternating.

   . Faraday's Law

   . direction of e.m.f. changes when flux changes from increasing to decreasing

. flux is continuously increasing and decreasing, so polarity and direction of e.m.f. is continuously changing

Faraday's law 答题套路一

1. sth causes magnetic field which causes magnetic flux in the coil
2. changing magnetic flux induces e.m.f in the coil by Faraday's law
3. induced current caused by the e.m.f. causes field around the coil
4. field around the coil oppose the field around sth by Lenz's law

(提及力的方向)

OR

1.

2.

3. e.m.f. causes currents in the disc

4. current in the magnetic field of sth causes force on the disc

（没有提及力的方向）

Transformer

1. why the core is made of iron

   increase flux linkage of secondary coil and reduce the loss of magnetic flux linkage

2. Explain why the core is laminated

   . reduces eddy currents in core

   . so that heating of core is reduced and less energy is lost as thermal energy

3. why an electromotive force (e.m.f.) is not induced at the output when a constant direct voltage is at the input. (By reference to the action of a transformer, explain why the input to the transformer is an alternating voltage, rather than a constant voltage.)

   . e.m.f. is induced only when flux in core is changing

   . direct voltage gives constant flux, so the magnetic flux linkage of secondary core does not change

   (alternating voltage produce changing magnetic flux in core, so the magnetic flux linkage of secondary core is changing)

4. State **one** function of a transformer.

   to change magnitude of potential difference

5. Explain why, when there is an alternating current in the primary coil, there is a current in the load resistor connected with the secondary coil.

   . current in primary coil causes magnetic flux

   . changing current causes changing magnetic flux in core

   . so the magnetic flux linkage of secondary coil changes

   . e.m.f. in secondary coil is induced which causes current in resistor

charged particle

1. Explain why the path of the electron in the magnetic field is the arc of a circle.

   . magnetic force is always normal to the direction of motion

   . magnitude of magnetic force constant because speed is constant

   . so provides the centripetal force

2. The electron in velocity selector is now replaced by an α - particle traveling at the same speed *v* along the same initial path as the electron. Describe and explain the shape of the path in the region of the magnetic and electric fields.

   . straight line without deviation

. condition for whether the particle will deflect only depends on v and does not depend on m or q

3. Explain why the speed of the particle is not affected by the magnetic field.

   . the force on the particle is always perpendicular to the direction of travel

   . no work is done by the force on the particle

4. Explain how a uniform magnetic field and a uniform electric field may be used as a velocity selector for charged particles.

   . electric and magnetic fields are at right-angles to one another

   . charged particles enter the fields with velocity normal to the two fields

   . forces on particles due to both fields are in opposite directions

   . if forces are equal, the particles will have no deviation and such particles have the selected velocity.

Hall voltage

1. why a Hall probe is made from a *thin slice* of material

   . Hall voltage depends on thickness of slice

. thinner slice can produce larger Hall voltage

2. Suggest why the Hall voltage is difficult to detect in a thin slice of copper.

. in metal, n (number density of electrons) is very large

. therefore V_H is small because Hall voltage is inversely proportional to number density of charge carriers

(V_H=BI/ntq)

3. Explain why a constant voltage V_H is developed between the faces

. charge carriers moving normal to magnetic field

. charge carriers experience a force normal to I and B

. charge build-up results in electric field across the slice and p.d. across the slice

. charge stops building up and V_H becomes constant when F_B = F_E

4. For the same values of magnetic flux density and current, state which slice, if either, will give rise to the larger Hall voltage. Explain your reasoning. (metal and semiconductor)

. V_H inversely proportional to number density of charge carriers

. number density of charge carriers (n) lower in semiconductors

so V_H larger for semiconductor slice

VI. Nuclear Physics

decay

1. Define radioactive *decay constant*.

   probability of decay of a nucleus per unit time

2. State what is meant by *radioactive* （*decay*）.

   spontaneous emission of particles by unstable nucleus

3. Explain what is meant by the decay being *random*

   time at which a nucleus will decay cannot be predicted

4. Explain what is meant by the decay being spontaneous

   decay is not affected by environmental factors

5. if temperature increases, will half life change?

   no change because decay is spontaneous and independent of environment

6. Explain why, after the decay, the nucleus is no longer stationary.

   nucleus must have momentum in opposite direction of photon due to the conservation of momentum

fission and fusion

1. Define the *binding energy* of a nucleus.

   energy required to separate the nucleons in a nucleus to infinity

2. fusion: two nuclei combine to form a single nucleus and binding energy per nucleon increases

   fission: a single large nucleus divides to form smaller nuclei. a small number of neutrons are released and binding energy per nucleon increases

3. features:

   . **fusion** is initiated by very high temperatures and pressure

   . **fission** is initiated by neutron bombardment

   . both binding energy per nucleon increases, total binding energy increases and release energy

4. State what is meant by the *mass defect* of a nucleus.

difference between mass of nucleus and mass of its nucleons where nucleons are separated to infinity

5. Suggest why a nucleus of helium - 4 does not spontaneously break down to become nuclei of hydrogen.

   . amount of energy released in forming hydrogen isotopes

   -is less than energy required to break apart helium nucleus

   because binding energy per nucleon of helium is much greater

   . so it would require a large amount of energy to separate the nucleons in helium and the reaction requires a net input of energy

6. explain why the reaction would **not** result in an overall release of energy.(Fe-56 的裂变)

   . binding energy per nucleon is a maximum at Nucleon number =56

   . products of splitting a ^{56}Fe nucleus must have a lower total binding energy

   (energy released is smaller than the energy required)

   reaction would require a net input of energy

activity

1. Suggest two other reasons why the activity and the measured count rate may be different.

   . emission from radioactive daughter products of the decay

   . background radiation

   (Radiation is emitted in all directions

   The detector does not surround the source.)

2. Suggest a reason why the actual activity and the calculated activity may be different. (实际的 A 要高)

   . the decay product is radioactive

   -as an additional source of activity

3. how about the measured count rate for any specific time when temperature increases?

   count rate is random and cannot be predicted

4. State and explain whether the binding energy per nucleon of uranium-235 (^{235}U) will be greater, equal to or less than La

   . above A = 56, binding energy per nucleon decreases as A increases

   . U-235 has larger nucleon number

. so less binding energy per nucleon

5. In an α-particle scattering experiment, the beam of α-particles is incident on a very thin gold foil. Suggest why the gold foil must be very thin.

so that single interactions between nucleus and α-particle can be studied

VII. Quantum physics

photon and electron

1. State what is meant by a *photon*.

. packet of energy

-of electromagnetic radiation

2. Explain why absorption spectrum contains a number of dark lines.

. electron absorbs energy of a photon

. photon energy causes electron to move to higher energy level

. photon energy absorbed is equal to the difference in energy levels

. during de-excitation of electrons, photons are emitted in all directions, so there are some dark lines

3. Describe the appearance of a visible line emission spectrum, as seen using a diffraction grating.

   dark background with coloured lines

4. Briefly describe two phenomena associated with the photoelectric effect that cannot be explained using a wave theory of light.

   . frequency below which electrons are not ejected

   . maximum energy of electron depends on frequency

   . maximum energy of electrons does not depend on intensity

   . no time delay between illumination and emission of electrons

5. State what is meant by the *de Broglie wavelength*.

   particle has a wavelength dependent on its momentum when particle is moving

6. Describe the photoelectric effect.

. emission of electron

-when electromagnetic radiation is incident on surface

7. Explain why most of the emitted electrons will have a speed lower than v_{MAX}.

. electrons which are initially at surface and emitted from surface have the maximum kinetic energy

. energy is required to bring electron to the surface

8. By reference to the photoelectric effect, explain what is meant by *work function energy*.

minimum energy of a photon required to remove an electron

VIII. Ideal gas

1. State what is meant by an *ideal gas*.

. gas that obeys equation pV = constant × T

. symbols p,V and T explained

2. Describe the motion of molecules in a gas, according to the kinetic theory of gases.

. motion is random

. with constant velocity between collisions

3. what is seen through the microscope when Smoke particles are suspended in still air (Describe what is observed when viewing Brownian motion that provides evidence)

   smoke particles, shown as specks of light, are always moving haphazardly and randomly

4. how Brownian motion provides evidence for the nature of the movement of gas molecules.

   gas molecules move randomly and collide with smoke particles

   this causes changes of direction and the haphazard motion of the smoke particles

5. State what is meant by the symbol $\langle c^2 \rangle$.

   mean square speed of molecules

6. Explain why, for an ideal gas, the change in internal energy is directly proportional to the change in thermodynamic temperature of the gas.

. in ideal gas there is no intermolecular forces so there is no potential energy

. internal energy is equal to the kinetic energy of particles

. mean kinetic energy of particles is proportional to temperature of gas

7. Explain how movement of the gas molecules causes pressure in the container.

. molecule collides with wall

. momentum of molecule changes during collision with wall force on molecule so force on wall

. many forces act over surface area of container exerting a pressure

8. assumptions of kinetic theory of gases
    1) total volume of molecules is negligible compared with volume occupied by the gas which is the volume of the container
    2) A gas contains a very large number of atoms.
    3) There is no intermolecular forces between particles, except during collisions.
    4) motion is random with constant velocity between collisions

5) The collisions of particles with each other and with the container are perfectly elastic

IX. thermodynamics (first law of thermodynamics)

1. State what is meant by the *internal energy* of a system.

   sum of potential energy and kinetic energy of random motion of particles

2. Use kinetic theory to explain why, during the melting process, thermal energy is required although there is no change in temperature.

   . during melting, bonds between molecules are broken

   . potential energy of molecules is increased

   . there is no work done on the solid so thermal energy is required as the input energy

3. what may be deduced from the difference in the temperatures of two objects

   direction and rate of transfer of thermal energy

4. the basic principle by which temperature is measured.

uses a property of a substance that changes with temperature

5. explain why two thermometers may not give the same temperature reading for an object.

. temperature scale may assume linear change of property with temperature

. actual properties may not vary linearly with temperature

they may only agree at fixed points

6. State what is meant by *specific latent heat (of fusion)*

thermal energy required per unit mass to cause change of state (between solid and liquid) at constant temperature

7. Energy is supplied continuously by the heater to the water(100℃). State where external work is done

work done against the atmosphere

where internal energy increases

. water because it turns from liquid to vapour which means potential energy of molecules increases

. surroundings because some energy is transferred to surroundings. its temperature rises so kinetic energy of molecules increases

8. state and explain the change, if any, in the internal energy of a lump of solid lead as it melts at constant temperature by reference to the first law of thermodynamics

. little volume change so there is little external work done

. thermal energy is supplied to provide latent heat

. internal energy increases

9. state and explain the change, if any, in the internal energy of some gas in a toy balloon when the balloon bursts and no thermal energy enters or leaves the gas.

. volume of gas increases

. gas does work against the atmosphere

. internal energy decreases

10. $\Delta U = q + w$. State, for a system, what is meant by +q

energy transferred to the system by heating

what is meant by +w

external work done on the system

11. Explain why, although the power of the heater is changed, the rate of loss of thermal energy to the surroundings may be assumed to be constant.

temperature difference between liquid and surroundings does not change

X. alternating current

1. Explain why heating occurs when there is an alternating current in a resistor even if the mean current is zero.

. heating depends on current^2 (I^2)

. current^2 (I^2) is always positive

2. why high voltages are used

. if power of transmission is constant, higher voltage means lower current

. lower current means less power loss in transmission cables

3. why the voltage is alternating.

. voltage can be easily stepped up and down by a transformer

. transformers only work with a.c.

. generators produce a.c.