STATE EXAMINATIONS COMMISSION

LEAVING CERTIFICATE EXAMINATIONS 2003

ENGINEERING – HIGHER LEVEL

MARKING SCHEME

Question 1. ***(100 marks)***

SECTION A - 50 marks

(a) **Narcotic effects** result from inhalation and ingestion of toxic substances and may involve loss of sensibility, drowsiness and unconsciousness in severe cases. Solvents used in paints, adhesive and polishes are common sources. **Irritant effects** result from contact with toxic materials, this may lead to dermatitis swelling and cracking of skin and in severe cases skin cancer. Contact with mineral oils, water based emulsions, cutting fluids and fluxes may cause these conditions. **3 + 2**

(b) A materials mass, density, electrostatic and magnetic properties may be used to facilitate ore dressing. **3 + 2**

(c) Casting or machining. **5**

(d) In an **ionic bond**, the atoms of the material are held together by electrostatic attraction between positively and negatively charged ions.
In a **covalent bond**, atoms bond together by sharing electrons. The bonds between the atoms in an ethylene molecule are covalent bonds. **3 + 2**

(e) **Name**: Diode.
Purpose: To allow current to flow in one direction only, often used to protect other components in a circuit. **3 + 2**

(f) **Flashback arrestors** are used to prevent the flame returning through the hose into the regulator. **5**

(g) An aluminium alloy would be suitable because it is non-corrosive, attractive, light and a good reflector of light and heat. **2 + 1 + 1 + 1**

(h) Corrosion rate is affected by pollutants dissolved in rain, atmospheric pollution, climate, moisture and wind. **3 + 2**

(i) Pneumatic power is a safer and cheaper power medium. **3 + 2**

(j) Components are given a **factor of safety** when they have been designed to withstand greater loads than they will be subjected to. This significantly reduces the risk of failure. If a component is to withstand a load of 100N and is designed to withstand 300N the factor of safety is 3. **5**

(k) The cylinder on the left is a single acting cylinder and the cylinder on the right is a double acting cylinder. **3 + 2**

(l) (i**) Germain Sommeiller**: In 1887 invented the compressed air drill, he was also chief designer for Mont Censis tunnel in the Alps from Italy to France.

(ii) **Jack Kilby**: In 1958, he co-invented the integrated circuit where complete sets of electronic components could be embedded, and connected, to create a complex circuit, ie. the microchip.

(iii) **Chester Carlson**: In 1938, he duplicated the first, blurred photocopy image. **5**

(m) The rack and pinion mechanism shown can be used in car steering mechanisms and for the up and down movement of a drill spindle, using the feed lever. **3 + 2**

SECTION B - 50 marks

(n) The function of a compressor is; to take in refrigerant vapour at low pressure, compress it, and discharge it as high pressure superheated vapour to the condenser. **10**

(o) There are five basic types of compressors in use, Reciprocating, Rotary, Screw-type, Centrifugal and Scroll. **4 + 3 + 3**

(p) (i) Reciprocating compressor. **5**

(ii) Vapour flows into the compressor cylinder through the intake valve in diagram (b). The piston moves down drawing more vapour into the cylinder during the intake or suction stroke, see diagram (c). Now in the compression stroke the piston forces the vapour into a small space in diagram (d). This action increases the vapour pressure and temperature. The compressed vapour is pushed through the discharge valve into the condenser in this continuous cycle. **12**

(q) A compressor system which does not have a compressing member, is a non-positive displacement compressor. In centrifugal compressors compression is achieved by means of a centrifugal force, developed as the vapour is rotated by a high speed impeller. **3**

(r) (i) Low pressure side: Refrigerant flow control, evaporator and the suction line. **3 + 2**

(ii) High pressure side: The compressor, discharge line, the condenser, the receiver tank and the liquid line. **3 + 2**

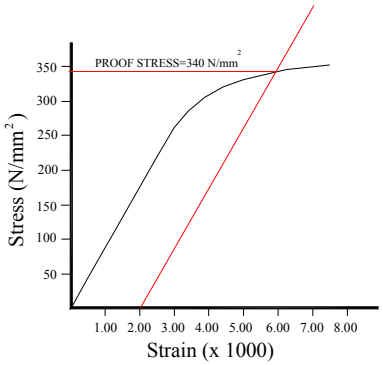
Question 2 *(50 marks)*

(a) (i) Creep is the slow deformation of a metal over time, resulting from a steady

force acting on the metal. **8**

(ii) Factors affecting the creep behaviour include, the temperature of the metal, the nature of the load on the metal and time constraints. **4 + 4**

(b) Plot stress – strain graph. **10**



(i) The 0.2% proof stress from the graph is 340 N/mm► **4**

(ii) Youngs Modulus of Elasticity E is 220/0.0025 = 88,000 N/mm² or 88kN/mm². **4**

(c) (i) The following non destructive test may be used to detect internal faults:

- Ultrasonic testing.
- Radiographic or X-ray testing.
- Eddy Current testing.
- Magnetic Particle testing. **(Any two) 5 + 5**

(ii)

- Ultrasonic testing: This test is based on pulse reflection. A probe is passed over the test specimen, sending high frequency vibrations which are reflected back on contact with lower surface of the specimen. When a void or flaw is present, vibration will be reflected back from this point. These will show up on the cathode ray tube as smaller peaks.

- X-ray testing: Radiation from an X-ray tube is passed through the specimen and this develops a photographic image of the specimen. Any defects present will show up as a darker image on photographic film.

- Eddy Current testing: This method is suited to both surface and internal defects for non-ferrous metals. An induction coil using alternating current sets up an Eddy Current in the specimen being tested. Any flaws present will change the flow of current. This is displayed in the screen of an oscilloscope.

- Magnetic Particle testing: Magnetic particles are applied to the surface of the specimen. The specimen is then magnetised. If flaws are present the magnetic particles form an arrangement around the fault. This method is used on magnetic materials such as steels and cast irons. Magnetic particles can detect defects up to 18 mm below the surface of a weld. The component should be demagnetised after the test. **(Describe) 3**

  (Diagram) 3

Question 3 *(50 marks)*

(a) (i) Ferrite is iron which contains a maximum of 0.02% carbon dissolved in solid solution. It is almost pure iron and has a body centered cubic structure.

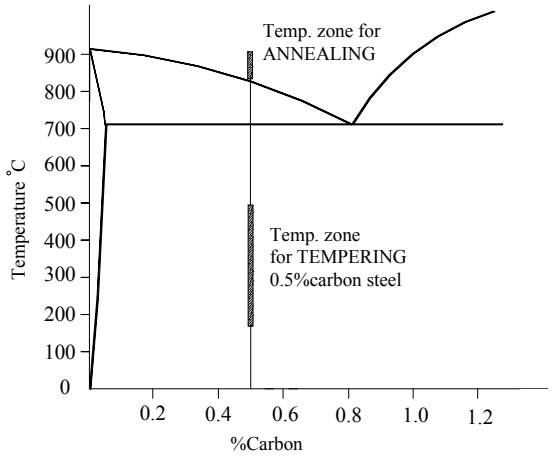
(ii) Cementite is an inter-metallic compound of iron and carbon, (Fe_3C). It is a very hard and brittle material. A steels hardness and brittleness increases as the amount of cementite increases.

(iii) Martensite is a hard needle like structure, which is strong but very brittle. This distorted structure occurs due to excess carbon having insufficient time to come out of solution during rapid quenching in hardening.

(iv) Tempering removes much of the brittleness present in martensite. It involves heating the steel to 500˚C and cooling it rapidly. This allows time for some of the carbon to diffuse out of the BBC structure producing a tougher, less brittle steel.

(v) Normalising removes internal stresses and refines abnormal grain structures which occur during hot or cold rolling and forging. The steel is heated to approximately 50˚C above its upper critical temperature and allowed cool in air. This improves machinability. **(Any two) 9 + 9**

(b) **(Copy diagram) 4**

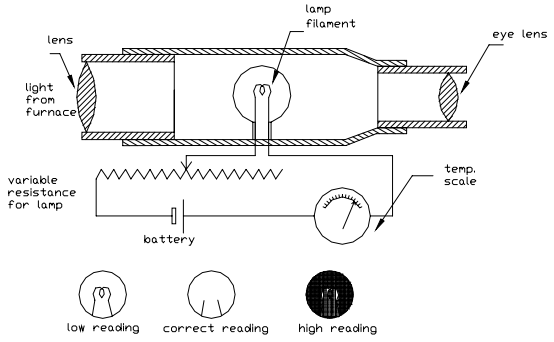


(i) Annealing: This process fully softens the steel. The steel is heated to above its upper critical temperature. It is then allowed to "soak" in the furnace at this temperature. Cooling is controlled by, reducing the temperature of the furnace gradually. **7**

(ii) Tempering produces steel in a tough condition.See Q.3 (a) (iv). **7**

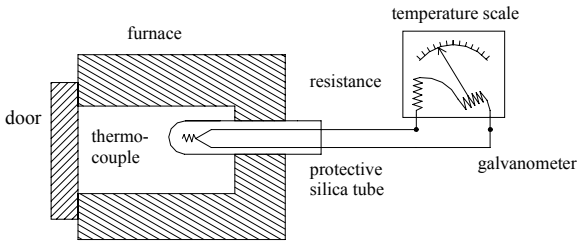
(c) (i) Optical pyrometer and the thermo-electric pyrometer. **3 + 3**

(ii) Optical pyrometer: The optical pyrometer compares the intensity of the light coming from the filament of a lamp. The current flowing in the lamp is adjusted to match the light from the furnace using a variable resistance. When a colour match is obtained the lamp filament disappears and temperature scale reading is taken.



OPTICAL PYROMETER

Thermo-electric pyrometer: If two dissimilar metals are joined together, with a Galvanometer placed in closed circuit at the open end, a rise in temperature of the joined end produces an electrical current which is recorded by the galvanometer. The galvanometer is calibrated to read in degrees of temperature instead of indicating electrical units.



THERMO-ELECTRIC PYROMETER

Applications for both would be measuring temperature in heat treatment furnaces.
(one description + application) 7 + 1

Question 4 *(50 marks)*

(a) (i) **Interstitial solid solution** occurs where small solute atoms fit into the spaces between the parent or solvent atoms. **Substitutional solid solution** occurs when the parent or solvent atoms are directly substituted by the atoms of the alloying or solute metals.

(ii) **Crystalline structures** have regular, repeating, geometrical molecular patterns. **Amorphous structures** have disorganised, irregular molecular patterns.

(iii) A **solvus** line defines the temperature at which a solid to solid change of structure occurs.

A **solidus** line describes the temperature where solidification ends. Below this line the structure is completely solid.

(iv) In a **BBC** structure, atoms are arranged so that their centres are positioned at the corner of a cube, with one atom in the centre of the cube. This structure is associated with brittleness in metals.

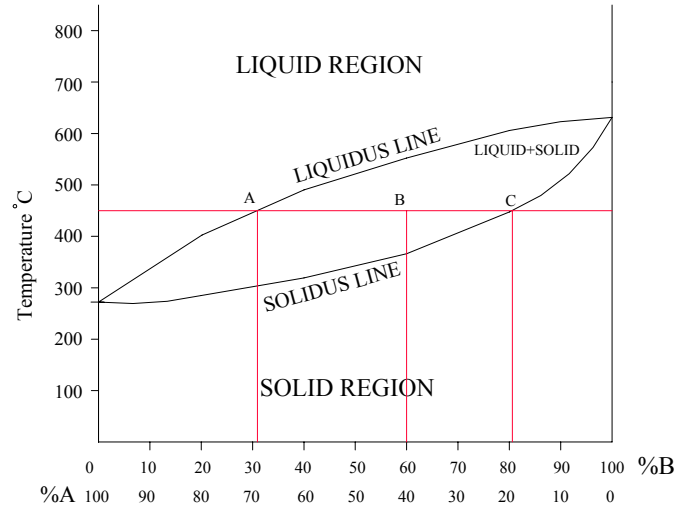
In an **FCC** structure atoms are arranged so that their centres are positioned at the corners of a cube, with one atom at the centre of each face of the cube. In this structure atoms are more tightly packed which facilitates ductility in metals.

(v) **Simple Eutectic**: The two metals are completely soluble in the liquid state but insoluble in the solid state. On cooling, two separate types of crystals or grains are formed.

Solid solution: When two metals are completely soluble in each other in both the liquid and solid states. When the alloy solidifies only one type of crystal is formed and it looks like a pure metal.

(Any two) 8 + 8

(b) (i) Draw equilibrium diagram: **7**



(Labels) 5 x 1

(ii) **Liquidus**: For the alloy system this line represents the boundry between the fully liquid state and the beginning of solidification.

Solidus: The boundry line that determines the end of solidification.Below this Line the alloy is completely solid.

Pasty Region: Between the liquidus and solidus line the alloy system is in a part liquid part solid state.

Liquid region: The two metals A and B are soluble in a liquid state.

Solid region: The two metals A and B are soluble in a solid state.

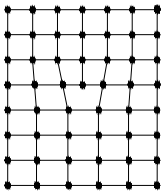
(Describe) 5 x 1

(iii) The ratio of solid to liquid is determined by using the lever rule:

$$\frac{\text{weight of solid}}{\text{w eight of liquid}} = \frac{ba}{bc} = \frac{29}{21}$$

3

(c) (i) A dislocation occurs where a line of atoms in a materials structure is incomplete. Stressing the structure causes the dislocation to move and the material yields.



(Description) 5

(Diagram) 5

(ii) Alloying with atoms of another element or cold working the metal. **4**

Question 5 *(50 marks)*

(a) (i) Resistance Spot Welding. **4**

(ii) The components to be joined are placed between two electrodes and pressed together. Current is passed through the electrodes, and the resistance to this current causes local rapid heating at the interface, resulting in a nugget type spot weld. **10**

(iii) Used for welding car bodies, joining sheet metal. **4**

(b) (i)

- Oxygen should never be used instead of compressed air.
- Special care is needed when using pressurised and flammable gases.
- Use of goggles to protect ones eyes from harmful light rays.

(ii) Functions of the electrode coating include:

- To generate a shield of carbon dioxide gas to protect welded joints from contamination by oxygen and nitrogen in the air.
- To form a slag coating which protects the weld from oxidation and ensures a slow cooling rate for the weld thus preventing cracks and brittleness.

(iii) Multi runs are superior to single run welds due to a post heating effect occurring after each weld run. This refines the material's structure, and strengthens the weld.

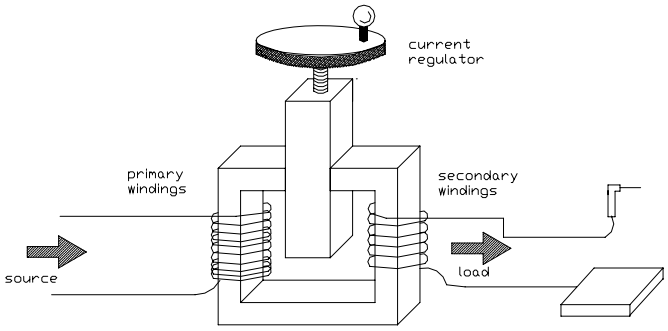
(iv) Primary combustion occurs in the innermost cone, where acetylene and oxygen burn to form carbon monoxide and hydrogen.

$C_2H_2 + O_2 \rightarrow 2CO + H_2$

Secondary combustion occurs in the outer envelope, where the carbon monoxide and hydrogen burn with oxygen from the surrounding air, to form carbon dioxide and water.

$CO + H_2 + O_2 \rightarrow CO_2 + H_2O$ **(Any three) 7 + 7 + 7**

(c) In manual metal arc welding, a step down transformer is used to change the mains voltage from 220v to a suitable level (usually 80-100 volts) for welding. This will in turn give a high current suitable for welding. For a step down transformer there are more turns on the primary coil, which induces ac at lower voltage in the secondary coil as it has fewer turns. **(Describe) 6**
(Diagram) 5



Step-down transformer

OR

(c)

- Less human error/increased accuracy.
- Consistent quality of weld.
- Can be programmed to carry out a variety of procedures. **6 + 5**

Question 6 *(50 marks)*

(a) (i) Injection moulding: Plastic granules of the thermoplastic materials are fed into the hopper. A plunger forces the plastic along the machine barrel where they are melted by the heaters and compacted by the torpedo. The softened polymer is then forced into the mould where it solidifies. The mould is opened and the plastic product is ejected. **8**

(ii) Milk crates, Golf tees are examples of end products. **3**

(iii) A = Mould C = Hopper E = Torpedo
B = Heater D = Plunger/Ram **5**

(b) (i) **Parison**: This is the thick walled tube used in blow moulding. The hot parison is blown into the shape of the mould.

(ii) **Monomer**: This is the basic unit, which form the building blocks for polymerisation.

(iii) **Vulcanisation**: This is the addition of sulphur to natural rubber. Sulphur acts as a cross-linking agent between adjacent chains. Vulcanised or synthetic rubber retains elastic properties because of the folded nature of these chains.

(iv) **Catalyst**: These speed up or slow down chemical reactions.

(Any two) 8 + 8

(c) (i) **Chemical Bonding**:

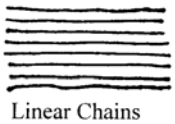
Thermoplastic: Chains are bonded by weak secondary covalent bonds called Van Der Waals Forces.

Thermosetting: Strong primary covalent bonds from a rigid 3-D structure.

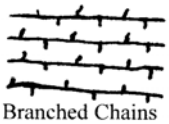
Elastomers: Natural rubber has molecular chains bodied by weak Van Der Waals Forces. Vulcanised or synthetic rubber has stronger covalent bonds between the cross-links. **2 + 2 + 2**

(ii) **Internal structure**:

Thermoplastics: A linear or a branched structure exists.



Linear Chains



Branched Chains

Thermosetting: A cross-linked structure exists.

Cross-linked Chains

Elastomers: Natural rubber has linear chain molecules which are of a folded nature.
Vulcanised rubber contains folded chains with cross-links causing the chains to be permanently bonded.


Natural Rubber


Vulcanised Rubber

2 + 2 + 2

(iii) **Properties**:

Thermoplastics: Properties include; low tensile strength, low melting point, easily disrupted by heat and flexible.

Thermosetting: Properties include; High melting points, tensile strength, stiff, Less flexibility, cannot be reheated and remoulded.

Elastomers: Tough, flexible, can be stretched but will return to their original shape, (both plastic and elastic). **2 + 2 + 2**

Question 7 *(50 marks)*

(a) A : Body: The section of a drill bit that contains the drill flutes.
B : Parallel shanks: This section of the drill bit is held in the chuck.
C : Flank: This determines the cutting lip length.
D : Flute: Drill flutes provide the cutting lips and a passageway for swarf to escape.
E : Land: This is the thickness of a cutting lip.
F : Web: This the metal at the centre of a drill point. **(Any three) 5 + 5 + 5**

(b) (i) Cutting fluids have the following benefits when machining:

- They act as a coolant for the cutting tool and the work piece.
- They lubricate and reduce friction between the tool and the chip and result in less power being consumed.
- Help wash away the machined chips.

(ii) The **sine bar** is a precision measuring instrument used to set up and measure angles accurately.

(iii) Two main methods of mounting milling cutters are:

- Arbor-mounted cutters.
- Chuck-mounted cutters.

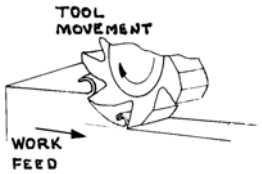
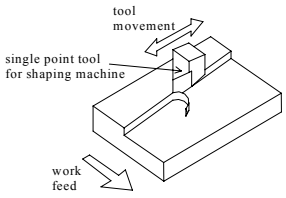
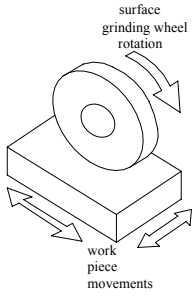
(iv) A **dividing head** is used to hold a workpiece so that it can be indexed for machining at specific increments around its periphery e.g. splines on shafts.

(Any three) 7 + 7 + 6

(c) (i) **Name:** **1 + 1 + 1**

Milling cutter e.g. cylindrical milling cutter.	Single point cutting tool on a shaping machine or for facing off during turning.	Grinding wheel for surface grinding.

(ii) **Method of operation:** **3 + 3 + 3**

A flat surface is generated by the action of a revolving milling cutter. The work is held rigidly on the machine table and it is fed into the rotating cutter. In some milling machines the cutter is fed into the work. 	To generate the flat surface with a single-point tool, there must be two relative motions. In shaping the tool reciprocates in one plane and the workpiece is fed at right angles to the movement of the tool. During each forward motion of the tool a chip is formed. As the tool returns to take the next cut the workpiece is fed by a small amount. 	The grinding wheel rotates at high speed and the worktable is fed, to and fro continuously. At the end of each stroke, the table is fed across towards the wheel by a small amount. The depth of cut is determined by lowering the wheel head. 

(iii) **Applications:** **1 + 1 + 1**

A wide variety of applications e.g. slots on work tables.	Machining of horizontal, vertical and inclined flat surfaces.	Produces extremely smooth surfaces, often seen as a precision finishing process.

OR

(c) (i) **Linear interpolation** is the movement of a cutting tool, to cut in a straight line at a selected feed rate. (G01)

(ii) **A canned cycle** enables a required number of repetive operations to be executed by a single programmed block. (G80-G84)

(iii) **Rapid traverse** is the movement of the tool rapidly to a designated position. (G00)

(iv) **A continuation code** allows you to exit a programme and continue writing at a later stage. (M99)

(v) **A stepper motor** is a special motor that runs on electrical pulses and turns a fraction of a revolution for each pulse. They are used to move the slides on CNC lathes. **(Any three) 5 + 5 +5**

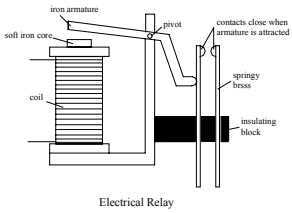
Question 8 *(50 marks)*

(a) (i) Vee pulley and V-belt: Used in lathes and drills, to transmit motion from motor to spindle.

(ii) Chain and sprocket: Used on bicycles, motorcycles, go-karts and the cornshaft drives, of some engines. **(Name) 9**

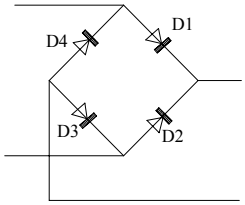
(Application) 8

(b) (i) Electrical relay: It changes electrical energy, into mechanical energy. It is very useful, if a small current in one circuit is required to control a device that needed a large current in another circuit, e.g. Electric motor-Door chime.



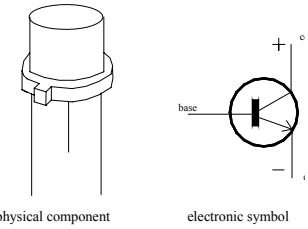
Electrical Relay

(ii) Rectifier: A rectifier permits current to flow in only one direction. For manual metal are welding it changes AC to DC.



RECTIFIER

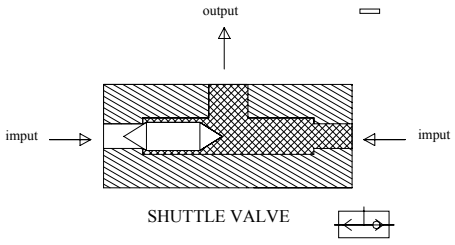
(iii) Transistor: transistors are semi-conducting devices with three leads. A very small current at one lead can control a much larger current flowing through the other two leads. It can be used as an amplifier or a switch.



physical component electronic symbol

TRANSISTOR

(iv) Shuttle valve: This valve is a non-return valve with two inlets and one outlet. It allows either of the two inputs to be connected to the output but prevent cross flow between inputs. It is used when a cylinder has to be controlled from two different points.



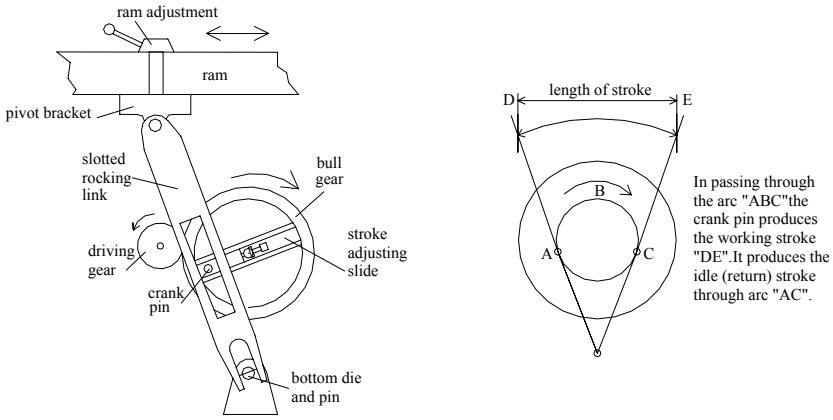
SHUTTLE VALVE

(v) Clutch: A clutch is used to make and break the drive between engine and car wheels. It facilitates gear changes when the drive is disconnected.

(Any two) 9 + 9

(c) **A Quick return mechanism:** is used on a shaping machine, to return the ram on the idle stroke at a faster speed than the cutting stroke. As the bull wheel rotates, the crank pin causes the slotted link to move the ram back and forth. The working stroke is produced when the crank pin rotates through arc "ABC" and

the shorter idle stroke is produced as it rotates through arc “CA”. The position of the crank pin can be adjusted by a lead screw which is rotated by level gears. The length of the ram stroke is reduced, if the crank pin is nearer the centre of the bull wheel.



Quick return mechanism

(Operation) 10

Function: To provide a return stroke which is faster than the cutting stroke as in the shaping machine. **(Function) 5**

OR

(c)

At room temperature the resistance of the thermistor is a lot greater than 10kΩ. This implies the potential difference across the thermistor is approx. 9V and approx. 0V across the 10kΩ resistor. In this state the base current is too small to switch on the transistor, thus the buzzer remains silent. As the temperature increases, the resistance of the thermistor decreases causing the potential difference across the 10kΩ to increase. In this state the potential difference across the 10kΩ resistor is sufficiently high to produce a large base current that switches on the transistor causes the buzzer to be activated. This type of device would be used where it is important to maintain temperature under a certain level, e.g. cold room. **(Operation) 10**

(Application) 5