



**SUMMER-19 EXAMINATION**  
**Model Answer**

Subject title: Mechanical Operation

Subject code

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**Important Instructions to examiners:**

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.



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Q No.	Answer	Marking scheme
<b>1</b>	<b>Attempt any FIVE of the following</b>	<b>10</b>
1	a <b>Size reduction equipment (any four)</b> Jaw crusher, gyratory crusher, hammer mill, roll crusher, ball mill,	½ mark each
1	b <b>Size reduction:</b> It is the method by which particles of solid are cut or broken into smaller pieces.	2
1	c <b>Screening equipment</b> Trommels, vibrating screen, , grizzlies	1 mark each for any 2
1	d <b>Principle of basket centrifuge:</b> Separation of solid particles from a slurry with the help of centrifugal force using a filter medium	2
1	e <b>Equipment used for gas-solid separation:</b> Cyclone separator, electrostatic precipitator, fabric filter, wet scrubber	½ mark each
1	f <b>Application of conveyor (Any two):</b> Conveyor systems are commonly used in many industries including the mining, automotive, agricultural, computer, electronics, food processing, aerospace, pharmaceutical, chemical, bottling and canning, packaging etc. Although a wide variety of materials can be conveyed, some of the most commonly conveyed materials include food items such as beans and nuts, bottles and cans, automotive components, scrap metal, pills and powders, wood and furniture and grain and animal feed.	1 mark each

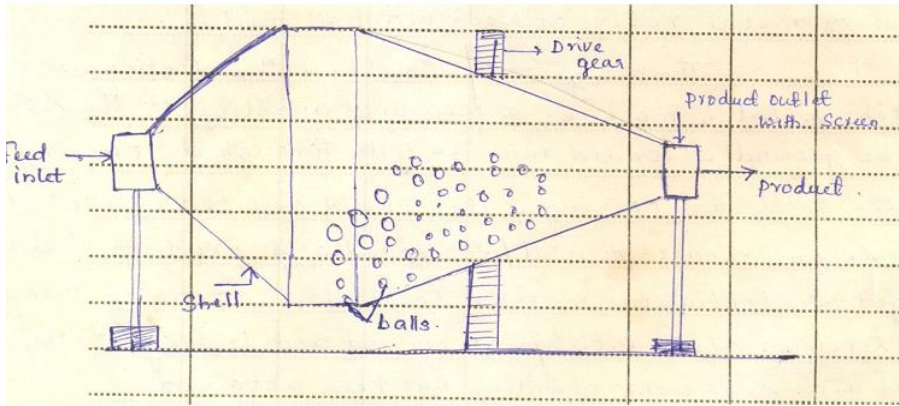
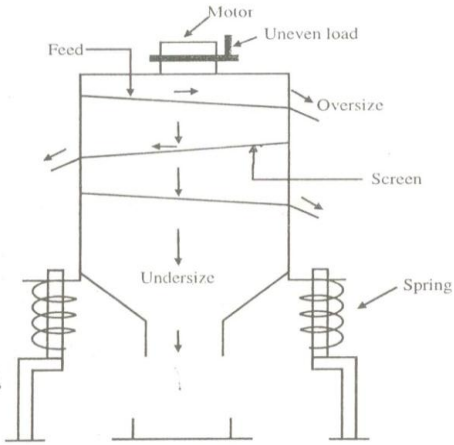


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1	g	<b>Types of agitators used in mixing:</b> Propellers, paddles and turbine	2
2		<b>Attempt any THREE of the following</b>	<b>12</b>
2	a	<b>Ball mill</b> <b>Diagram:</b>  <b>Principle:</b> Ball mill works on the principle of impact.	3  1
2	b	<b>Vibrating screen:</b> <b>Construction:</b> 	



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		<p>Generally the screens are provided with one, two &amp; maximum three decks, with the coarsest screen at the top, either horizontally or inclined up to <math>45^{\circ}</math>. Each screen is provided with a separate over flow. The undersize material from the last screen is collected from bottom. Due to inclination to screen, the oversize material travels along the screen.</p> <p><b>Working</b></p> <p>The screens are vibrated mechanically or electrically with a frequency of 1800 to 3600 per minute. Mechanical vibrations are transmitted from the high speed eccentrics to casing &amp; from there to screens so that the whole assembly is vibrated. In electrically vibrated screens, vibrations are transmitted from heavy duty solenoids directly to the screens.</p>	2
2	c	<p><b>Rotary drum filter:</b></p> <p><b>Diagram:</b></p> <p>The diagram illustrates a rotary drum filter. It consists of an inner drum and an outer drum covered with a cloth. Slurry is fed into a trough at the bottom of the inner drum. As the drums rotate, a cake of filter material forms on the outer surface. A wash spray is directed at the cake to clean it. A doctor blade is used to scrape the cake from the drum. The slurry trough is shown at the bottom of the inner drum.</p> <p><b>Working:</b></p> <p>Filter drum is immersed in slurry, vacuum applied to filter medium causes cake to deposit on outer surface of drum. Cake is washed by spraying wash liquid; wash liquid is collected in a separate tank. Then cake enters into drying zone as drum rotates where cake is partially dried by sucking air through cake</p>	2



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		of solids. Then vacuum is cut off & cake removed with a doctor's knife. Air is blown for removal of cake.	
2	d	<p><b>Cyclone separator:</b></p> <p><b>Diagram:</b></p> <p><b>Working:</b></p> <p>The dust laden gas is introduced tangentially into a cylindrical vessel at a high velocity (30 m/s). Centrifugal force throws the solid particles out against the wall of the vessel and they drop into a conical section of the cyclone and removed from the bottom opening. The clean gas is taken out through a central outlet at the top.</p>	2          2
3		<b>Attempt any THREE of the following</b>	<b>12</b>
3	a	<p><b>Kicks law</b></p> <p><b>Statement:</b> Kick's law states that the work required for crushing a given mass of material is the log of ratio of initial particle size to final particle size.</p> <p><b>Equation:</b></p> $\frac{P}{\dot{m}} = K_k \ln \frac{D}{d}$	2    2
3	b	<b>Hammer mill:</b>	



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		<p><b>Diagram:</b></p> <p><b>Explanation:</b></p> <p>It consists of a high speed rotor turning inside a cylindrical casing .Rotor is mounted on a shaft .The swung hammers(4 to 8) are pinned to a rotor disk having diameter 150 to 250 mm. The hammers are straight bars of metal with plain or enlarged ends .The product falls through the screen which forms the lower portion of the casing. The material to be crushed is fed from the top. The material is thrown out centrifugally &amp; crushed by being beaten between the hammer bars or against the breaker plates fixed around the periphery of the cylindrical casing. The material is beaten by the hammers until it is small enough to fall through a screen.</p>	2
3	c	<p><b>Froth flotation:</b></p> <p><b>Working:</b></p> <p>Water is taken into the cell; material is fed to the cell. Then promoters and frothers are added. Agitation is given and air is bubbled in the form of fine bubbles. Air-avid particles (hydrophobic) due to reduction in their effective</p>	2



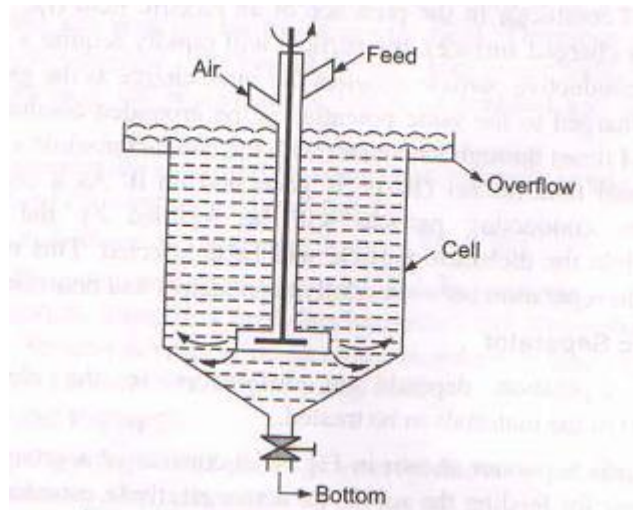
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density will rise to the surface and be held in the froth before they are discharged from the overflow. Hydrophilic particles will sink to the bottom and removed from the discharge for tailing.



**Applications (any two):**

- 1) For purification of Potassium chloride from sodium chloride and clay materials in presence of fatty ammonium salts
- 2) For recovery of sulphide ores
- 3) In mineral processing
- 4) Paper recycling
- 5) Waste-water treatment industries.

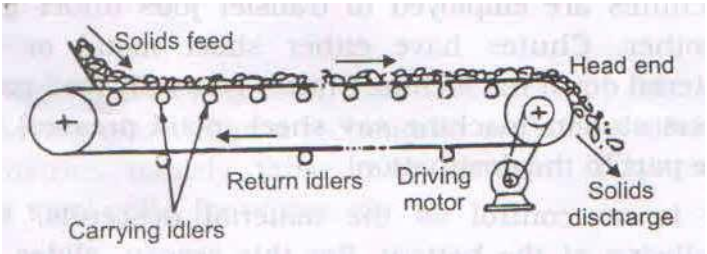
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3	d	<p><b>Belt conveyor:</b></p> <p><b>Construction:</b></p> <p>Belt conveyor consists of an endless moving belt of flexible material, stretched between two drums / pulleys and supported at intervals on idler rollers. The pulley that drives conveyor belt rotating is called drive pulley or transmission drum; the other one only used to change conveyor belt movement directions called bend pulley. Drive pulley is driven by the motor through reducer. The drive pulleys are generally installed at the discharge end in order to increase traction and be easy to drag. Proper idlers are selected and appropriately located to prevent belt sagging. Idlers are placed fairly close at the feed point and then farther apart and uniformly for the rest of the conveyor.</p> <p><b>Working:</b></p> <p>Material is fed on the feed-side and landed on the rotating conveyor belt, then rely on the conveyor belt friction to be delivered to discharge end. A clean discharge is vital for good belt life. On the return run, the carrying side of the belt is in contact with the return rollers and any material adhering to it is deposited on the roller. A belt cleaning device in the form of a revolving brush or rubber scraper blades is used for extremely sticky materials.</p> <p><b>Diagram:</b></p>  <p>The diagram illustrates a belt conveyor system. On the left, a hopper labeled 'Solids feed' is positioned above a large pulley. The belt runs from this pulley across a series of 'Carrying idlers' to a 'Head end' pulley on the right. A 'Driving motor' is connected to the head end pulley. From the head end, the belt returns to the feed pulley, supported by 'Return idlers'. At the head end, there is a 'Solids discharge' point. Arrows indicate the direction of belt movement and the flow of material.</p>	2
4	<b>Attempt any THREE of the following</b>		<b>12</b>





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4	a	<p>Data:</p> <p>Radius of Ball mill = <math>R = D/2 = 800 / 2 = 400 \text{ mm} = 0.4 \text{ m}</math></p> <p>Radius of Ball = <math>d/2 = 60 / 2 = 30 \text{ mm} = 0.03 \text{ m}</math></p> <p>The critical speed of Ball mill is</p> $N_c = 1/2\pi \sqrt{\frac{g}{R-r}}$ $N_c = 1/2\pi \sqrt{\frac{9.81}{0.4 - 0.03}} = 0.82 \text{ rps}$ <p>Operating speed of Ball mill = <math>N_c * 0.55</math></p> $= 0.55 \times 0.82 = 0.451 \text{ rps} = \mathbf{27.06rpm}$	<p>2</p> <p>2</p>
4	b	<p><b>Magnetic drum separator:</b></p> <p><b>Application (any two):</b></p> <ol style="list-style-type: none"><li>1) For removal of small quantities of magnetic material from a feed to a size reduction machine</li><li>2) In separation of Ferromagnetic particles such as iron and steel</li><li>3) Prevention of ferromagnetic or paramagnetic contamination in finished product</li><li>4) Most economical automatic iron removing equipment for large volume for dry powders, granules &amp; crushed materials.</li><li>5) Remove fine iron particles and iron oxides from mixed materials.</li><li>6) Used in Glass, pharmaceuticals, cement, metal recovery and plastic industries for the removal of iron bearing particles.</li></ol>	<p>1 mark each</p>

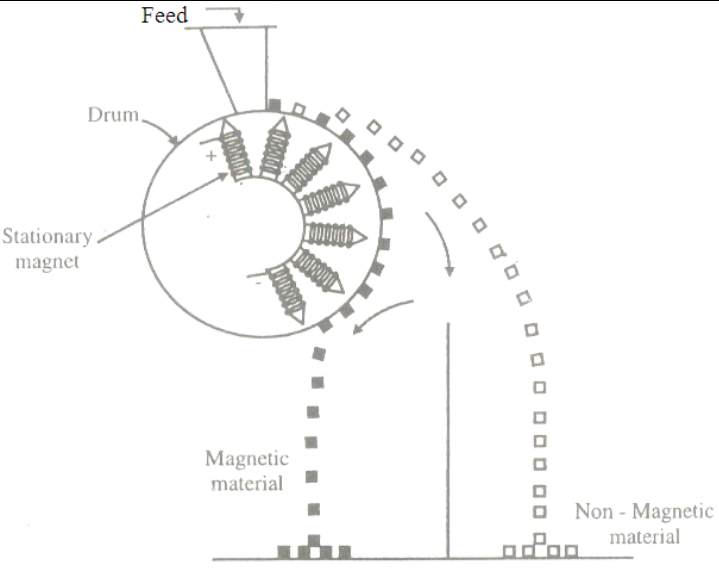


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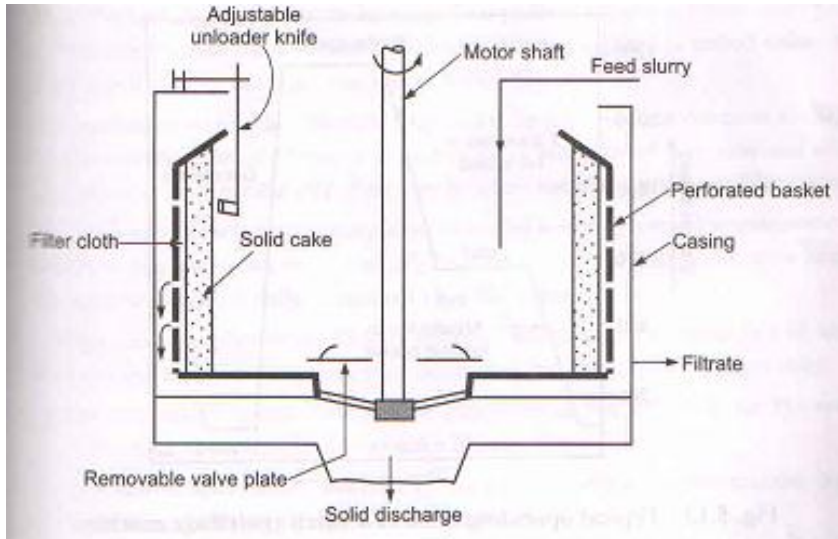
			2
4	c	<p><b>Gravity settling tank:</b></p> <p><b>Construction and working:</b></p> <p>It consists of a large tank with provision for inlet and outlet. As soon as the slurry feed enters the tank through the inlet, its velocity decreases because of enlargement of cross sectional area. The particles will settle under the influence of gravity. Large particles which have high terminal settling velocity settles first and they will be collected near the feed inlet. The slower settling particles will be carried further in to the tank before they reach the bottom of the tank. Intermediate particles will then settle and finally fine particles will settle. Very fine particles will be carried away by the flowing stream since they don't get sufficient time to settle.</p>	4
4	d	<p><b>Methods to avoid Vortexing :</b></p> <p>There are four methods of prevention of swirling and vortex formation</p> <ol style="list-style-type: none"><li>Off-center mounting of the impeller.</li><li>Use of Baffles</li></ol>	1 mark each



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		c) Use of diffuser ring with turbines d) Angular entry of agitators.	
4	e	<b>Basket centrifuge</b> <b>Diagram</b> 	2
		<b>Working:</b> Slurry fed to the rotating basket is forced against basket sides by centrifugal force. The liquid passes through the filter medium into the casing and out through a discharge pipe, while the solids form a filter cake against the filter medium. Cake is washed by spraying wash liquid to remove soluble material. Wash liquid leaves the centrifuge through the discharge pipe. After washing, cake is spun at higher speed. The cake is dislodged from the filter cloth with the help of an unloader knife.	2
5		<b>Attempt any TWO of the following</b>	<b>12</b>
5	a	<b>Electrostatic precipitator</b> <b>Construction:</b>	



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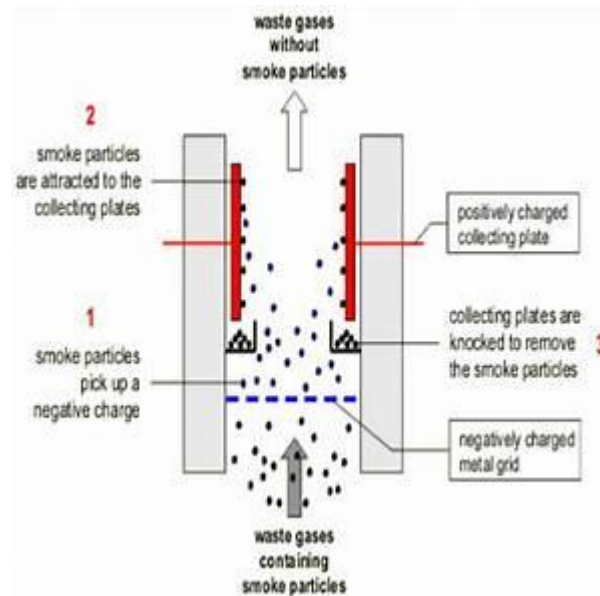
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The precipitator consists of vertical parallel plates (collecting plates/electrodes) forming gas passages 12 to 16 in. (30.5 to 40.6 cm) apart. Discharge electrodes are electrically isolated from the plates and suspended in rows between the gas passages. Every particle either has or can be given a charge - positive or negative.

**Working :**

A high voltage is applied to the discharge wires to form an electric field between the wires and the collecting plates and also ionizes the gas around the discharge wires to supply ions. When the gas that contains an aerosol (dust,mist) flows between the collecting plates and the discharge wires, the aerosol particles in the gas are charged by the ions. The Coulomb force caused by the electric field causes the charged particles to be collected on the collecting plates, and the gas is purified.



OR

2

2

2

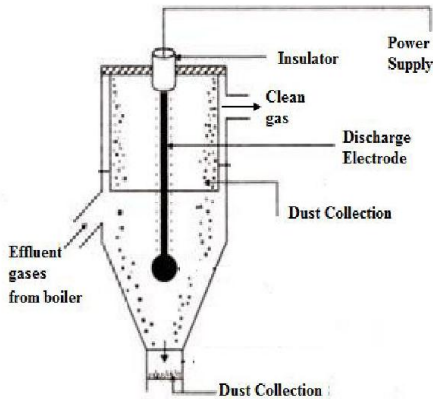


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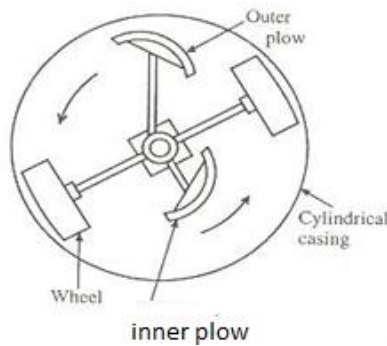
b

**Muller mixer:**

**Construction:**

It consists of a pan incorporating muller wheels. In some designs, pan is stationary & wheels rotate, while in other designs, pan is rotated & axis of wheels is held stationary. In stationary pan muller mixer, central vertical shaft is driven, causing the muller wheels to roll in a circular path over a layer of solids on pan floor. Plows guide the solids under muller wheels during mixing or to an opening in pan floor for discharge of mixer at the end of cycle

**Diagram:**



3

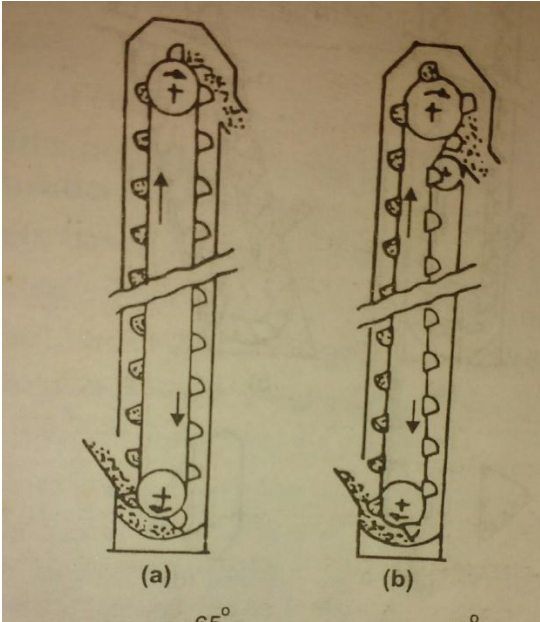
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5	c	<p><b>Bucket elevator:</b></p> <p><b>Principle :</b></p> <p>In spaced bucket centrifugal discharge elevator, buckets are mounted on a belt or chain and spaced to prevent interference in loading and discharging.</p> <p><b>Working :</b></p> <p>Buckets are loaded partly by material flowing directly into them and partly by scooping material from the boot. As the bucket reaches top, these will be inverted and the material will be off loaded. The empty bucket will again be loaded with material and so on.</p>  <p>(a) (b)</p>	<p>2</p> <p>2</p> <p>2</p>
6	<b>Attempt any TWO of the following</b>		<b>12</b>
6	a	<p><b>Types of Agitator(any two) :</b></p> <p>1) Turbine                      2) Propeller                      3) paddles</p> <p><b>1) Turbine :</b></p>	



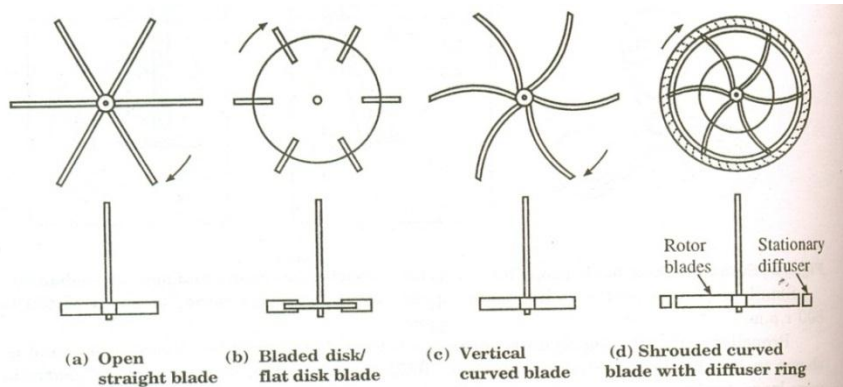
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**Diagram(any one)**

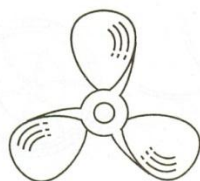


1 mark for diagram and 2 marks for explanation

**Explanation:**

The blade of turbine may be attached to a central hub or to a central disc. The diameter of the impeller is kept between one-third and one-sixth of the vessel diameter. The blade length is one-fourth of the impeller diameter. With a central disc, it is one-eighth of agitator diameter. Turbine speed usually range from 50 to 250 r.p.m. Turbine are very effective over a wide range of viscosities.

**2) Propeller :**



**Explanation:** A propeller is an axial flow, high speed impeller commonly used for low viscosity liquids. A propeller is shaped with a tapering blade to minimize the effect of centrifugal force and produce maximum axial flow. Propeller drives the liquid straight down to the bottom of the vessel, at the bottom the stream spreads radially in all directions towards the wall, then the



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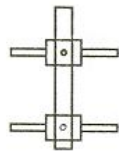
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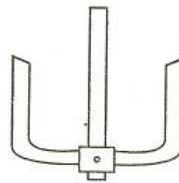
liquid flows upward along the wall. These agitators are used in situation where strong vertical currents are desired.

3) **Paddle:**

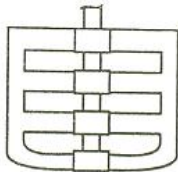
**Diagram(any one)**



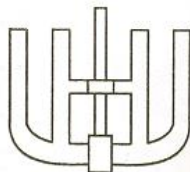
(a) Flat paddle



(b) Anchor



(c) Gate



(d) Combined anchor and gate

**Explanation:**

They usually have two or four blades. They are usually vertical and extends close to the vessel wall. The total length of the impeller lies between 50 to 80% of the inside diameter of the vessel. The width of the blade is one – fourth to one – tenth of the paddle diameter. In some designs, the shape of the blade is similar to the bottom of the vessel so that they can nscrap the surface with close clearance.

6 b

**Plate and frame filter press:**

**Description:**

It consists of plates and frames arranged alternately and supported on a pair of rails. The plate is a solid piece having a ribbed surface. The frame is hollow and provides the space for the filter cake. The plates and frames are square or





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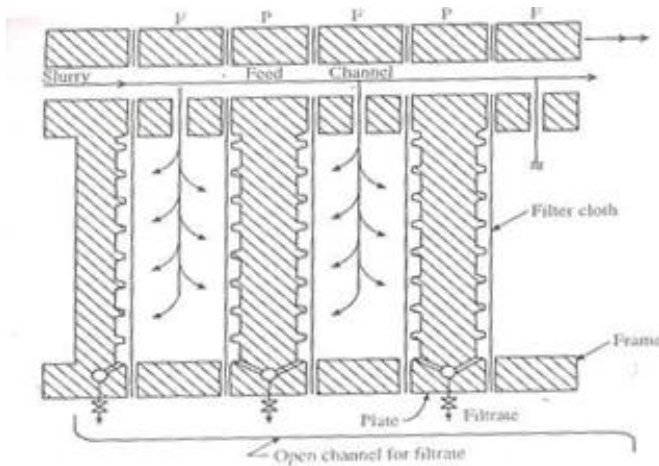
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rectangular in shape and can be made of cast iron, stainless steel, nickel etc. Filter cloths are placed over each plate to cover the plate surface on both sides so that hollow frame is separated from the plate by the filter cloth. The plates and frames have circular holes on the corners for feed and discharge. When the press is closed a continuous channel is formed along the whole length. At the bottom of the plate holes are cored which connect the face of the plates to the outlet.

Slurry to be filtered is pumped through the feed channel, it runs into chamber formed and fills chamber completely. As feed pump continues to supply slurry to be filtered, the pressure goes on increasing. Because of this, the filtrate passes through the filter cloth, run down the faces of plates and finally leaves the filter through discharge. The solid are deposited on the filter cloth. The two cakes are formed simultaneously in each chamber and these join when frame is full. The press is then dismantled and cake of solid scrapped off from each plate.



2

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6 c **Chain conveyor:**

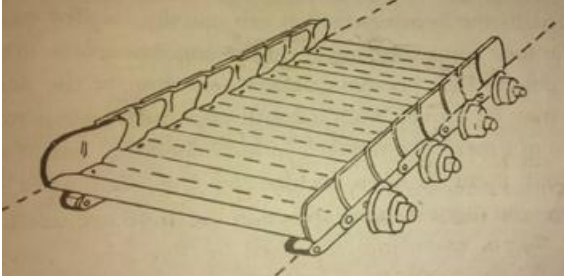


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	<p>They are different types of chain conveyor - Drag conveyor, flight conveyor, enmasse conveyor, apron conveyor etc</p> <p><b>Apron conveyor:</b></p> <p><b>Diagram</b></p>  <p><b>Explanation:</b></p> <p>These are mechanical conveyors which essentially consist of some form of endless chain which is drawn through the bulk solid to be conveyed. These conveyors consist of a close fitting series of metal pans supported between two strands of roller chain. The pans interlock or overlap with each other, thus forming a continuous moving platform on which bulk solids can be conveyed. In this respect, apron conveyors are similar to belt conveyors. These conveyors can handle heavy, large lumped, abrasive and hot materials. But these conveyors are heavy and expensive in terms of investment cost.</p> <p><i>(Due consideration should be given for any other type of chain conveyors)</i></p>	<p>2</p> <p>4</p>
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