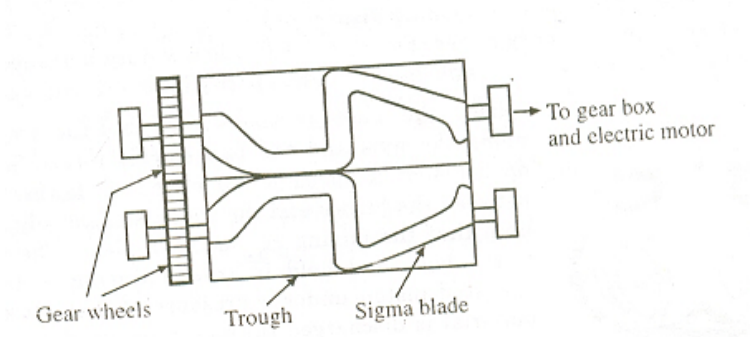
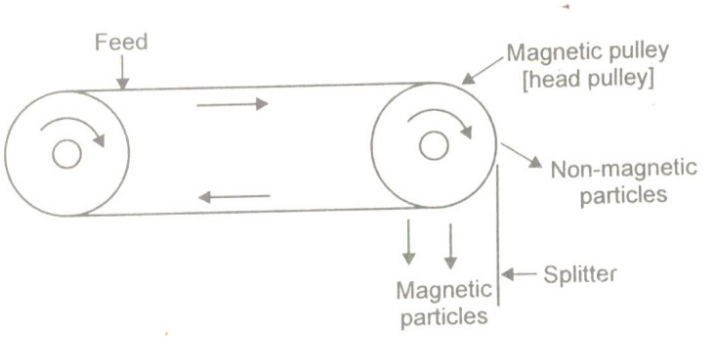
Important Instructions to examiners:

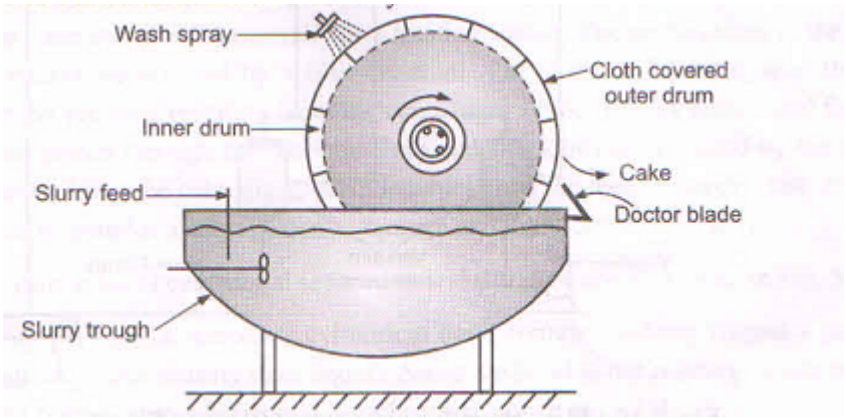
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

Q No.	Answer	Marks
1	**Attempt any SIX of the following**	12
1A-a	**Kick's law:** 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. $\frac{P}{\dot{m}} = K_k \ln \frac{\bar{D}_{sa}}{\bar{D}_{sb}}$	2
1A-b	**Difference between ideal screen and actual screen:(any two)** Ideal screen / Actual screen 1. The overflow will contain only particles larger than cut diameter / The overflow may also contain particles smaller than cut diameter 2. Underflow will contain only particles smaller than cut diameter / Underflow may also contain particles larger than cut diameter 3. Yields sharp separation / Does not yield sharp separation 4. Efficiency is 100% / Efficiency is less than 100%	1 mark each
1A-c	**Equipment used for classification of solids:** 1.Gravity settling tank 2. Spiral classifiers 3.Cone classifiers 4.Drag classifiers 5.Rake classifiers 6. Double cone classifiers.	1/2 mark each for any four
1A-d	**Types of impellers:** Propellers, paddles and turbines.	2
1A-e	**Tramp iron**: Iron courser than 1/8 inch (3.125mm) is called as tramp iron.	1 1 mark

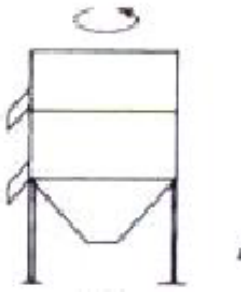
	Separation of tramp iron is necessary 1.To protect the size reduction machine against damage 2. To avoid unnecessary power consumption since it is unbreakable	for any 1 point
1A-f	(i) **Mesh:** It is the number of openings per linear inch counting from the center of any wire to a point exactly one inch distant. **(ii) Screening:** It is the separation of solid particles based on size.	1 1
1A-g	**Purpose of Mixing : (any two)** 1. To promote a chemical reaction , since intimate contact between reactingphases is necessary for reaction. 2. To produce simple physical mixtures – of two or more uniformly divided solids, two or more miscible liquids etc. 3. To carry out physical change- formation of crystals from a supersaturated solution. 4. To accomplish dispersion in which a quasi-homogeneous material is produced from two or more immiscible fluids and from one or more fluid with finely divided solids.	1 mark each
1A-h	**Crushing efficiency:** It is the ratio of surface energy created by crushing to the energy absorbed by the solid.	2
1 B	**Attempt any TWO of the following**	8
1B-a	**Sigma mixer:** **Construction**	

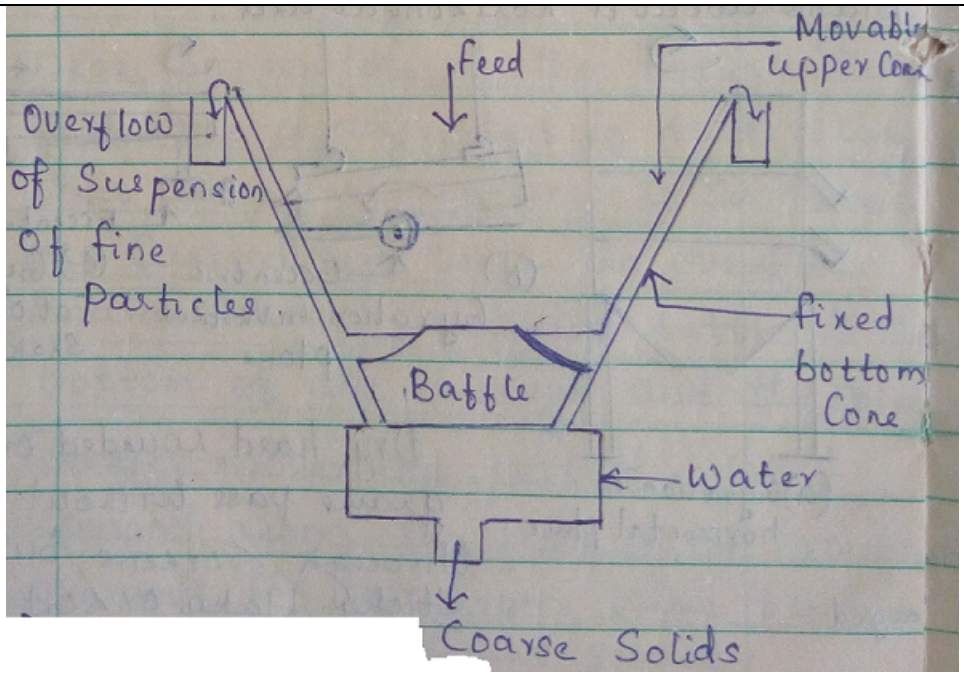
	 It consists of a short rectangular trough with saddle shaped bottom. Two counter rotating blades are incorporated in the trough. Blades are so placed and so shaped that the material turned up by one blade is immediately turned under adjacent one. The blades are driven by through a gear mechanism provided at either ends. The trough may be open or closed and may be jacketed for heating or cooling. The machine can be emptied through a bottom valve. **Working:** The material to be kneaded is dropped into the trough. The blades turn towards each other at the top, drawing the mass downward, then shearing it between the walls and blades of the trough. It is mixed forabout 5to 20 minutes or longer. The trough is then unloaded by tilting it.	2 2
1B-b	**Capacity of screen :** It is the mass of material that can be fed to unit area of screen in unit time. **Effectiveness of a screen:** It is a measure of success of the screen in closely separating oversize & undersize materials. Greater the capacity, minimum will be the effectiveness and lesser the capacity, maximum will be the effectiveness. The factors which tend to reduce capacity and lower the effectiveness are screen blinding, cohesion of particles to screening surface, oblique direction of approach of particles to the screen surface ,moisture in the feed etc.	1.5 1.5 1
1B-c	**Difference between pressure filter and vacuum filter:**	2 marks

	Pressure filter / **Vacuum filter** Super atmospheric (pressure greater than atmospheric pressure) pressure is applied on the upstream side / Atmospheric pressure is applied on the upstream side Atmospheric pressure is applied on the downstream side / Subatmospheric (pressure less than atmospheric pressure) pressure is applied on the downstream side	each
2	**Attempt any FOUR of the following**	**16**
2-a	**Necessity of size reduction :** Size reduction is done 1. To increase the surface area in order to increase the rate of physical or chemical process 2. To improve mixing of constituents in solid-solid mixing 3. To improve solubility 4. Easy packing and handling	1 mark each
2-b	**Magnetic head pulley** **Diagram**  **Working:** The magnetic head pulley is incorporated in a belt conveyor carrying feed material	2

	to the plant. The non-magnetic material is discharged from the pulley in a normal manner, while the magnetic material adheres to the belt and falls off from the underside where the belt losses its contact with pulley.	2
2-c	**Rotary vacuum filter:** **Working:**  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 of solids. Then vacuum is cut off & cake removed with a doctor's knife. Air blown for removal of cake.	4
2-d	**Difference between sedimentation and centrifugation:**	1 mark each

Sedimentation	Centrifugation
1. Separation of solids from a suspension in a liquid by gravity settling is called sedimentation.	1. Separation of solids from a suspension in a liquid by centrifugal force is called centrifugation.
2. Industrially sedimentation is carried out in equipment	2. Industrially centrifugation is carried out in equipment

	known as thickener. 3. Very less force of gravity & slow separation 4. Sedimentation is one of the most widely used processes in treatment of water.	known as centrifuge. 3. Very high centrifugal force & faster separation. 4. Centrifugation is widely used process in Sugar refining.		
2-e	**Gyrating screen:** **Working**  It consists of several decks of screen, one above the other, held in a box or casing. The coarsest screen is at the top and the finest at the bottom with suitable discharge ducts to permit removal of several fractions. Screens and casings are gyrated to push the particles through screen openings. Normally the casing is inclined at an angle to the horizontal.			4
2-f	**Double cone classifier:**			4



It consists of two cones- a fixed bottom cone and a movable upper cone. The upper cone can be lifted up or lowered down in a vertical plane inside the bottom cone so that a variable flow area is made available.

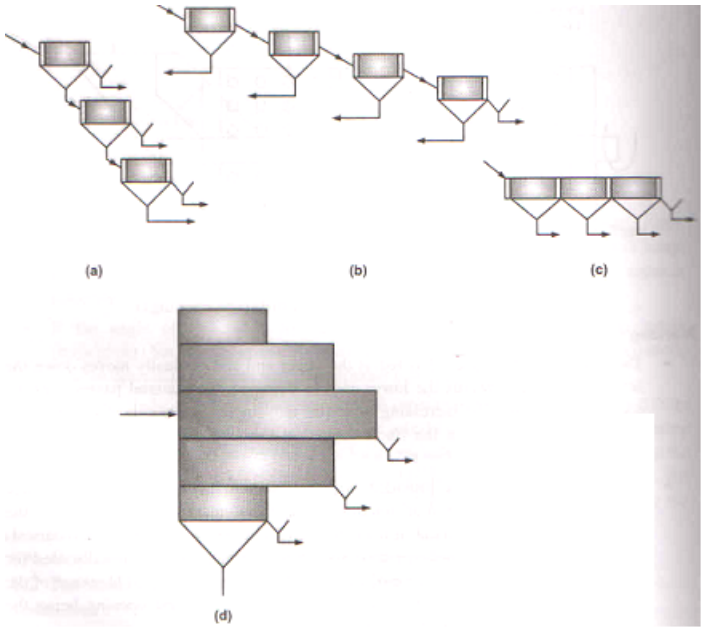
The feed material –slurry of suspended solids is fed to the upper cone. It moves downward and flows out of a baffle placed at the bottom of the movable cone. The slurry then moves up through the annular space. The fluid and the solids from the inner cone are mixed and then move up through the annular space with decreasing cross sectional area upwards. Classification occurs in the annular space – the larger particles settles to the bottom while the fine particles flow away with the overflow.

3	**Attempt any FOUR of the following**	**16**
3-a	**Muller mixer:** **Construction and Working:** 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	

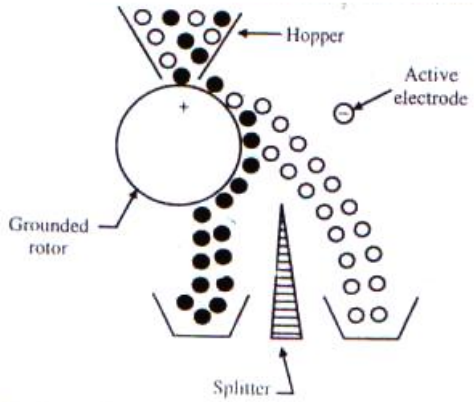
<table>
<tr><td></td><td>stationary.In stationary pan mullermixer, central vertical shaft is driven,causing the muller wheels to roll in a circular path over a layer of solids on pan floor. Plows guide the solids under muller wheels during mixing or to an opening in pan floor for discharge of mixer at the end of cycle. The rubbing action results from the slip of the wheels on the solids.</td><td>4</td></tr>
<tr><td>3-b</td><td>Classification of filters:
i) Based on function:
1) Clarifying filters /Deep bed filters
2) Cake filters
ii) Based on Driving force:
1)Gravity filters
2) Vacuum filters
3)Pressure filters
4) Centrifugal filters
iii) Method of operation:
1) Batch filter
2) Continuous filter</td><td>4</td></tr>
<tr><td>3-c</td><td>Difference between crushing and grinding:
Differentiation of Crushing and Grinding:
<table>
<tr><th>Sr.No.</th><th>Crushing</th><th>Grinding</th></tr>
<tr><td>1</td><td>Size reduction by compression</td><td>Size reduction by impact & attrition</td></tr>
<tr><td>2</td><td>Equipment operated in open-circuit</td><td>Equipment always operated in closed-circuit</td></tr>
<tr><td>3</td><td>Used for breaking of large pieces of solids into small</td><td>Used for reducing crushed feed to powder</td></tr>
</table></td><td>1mark each for any 4 points</td></tr>
</table>

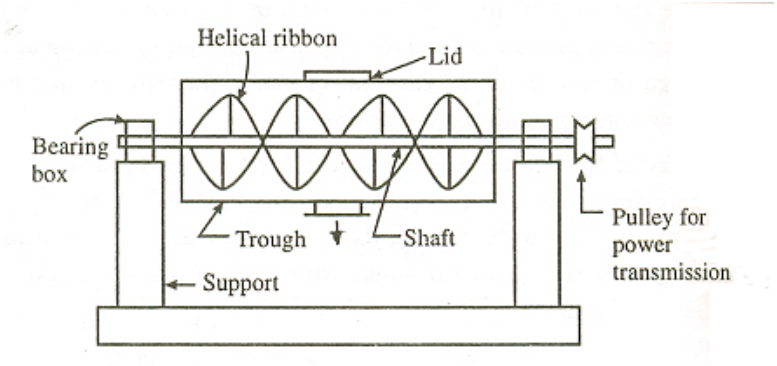
	lumps		
4	Reduction ratio exceeds 6 to 8.	Reduction ratio as high as 100 is possible	
5	Crushers are heavy duty,low speed machines.	Grinders are light duty,high speed machines.	
6	Feed size :1500 to 40 mm Product size: 50 to 5mm.	Feed size :5 to 2 mm Product size: 0.1mm.	
7	Operation is performed on dry feed.	Operation can be performed on dry as well as wet feed.	
8	Energy consumption per unit mass of product is low due to coarse particle production	Energy consumption per unit mass of product is high due to fine particle production	

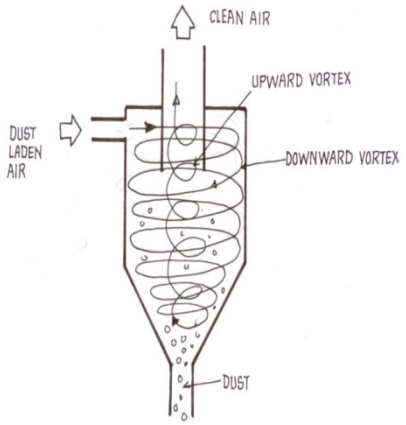
3-d **Different arrangement of trommels:** 1 mark each

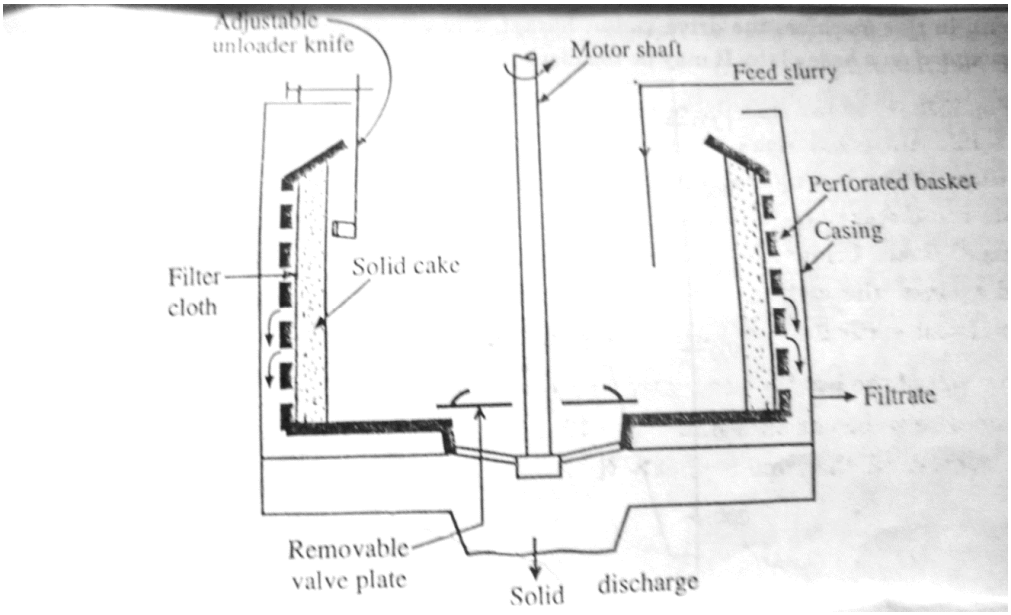


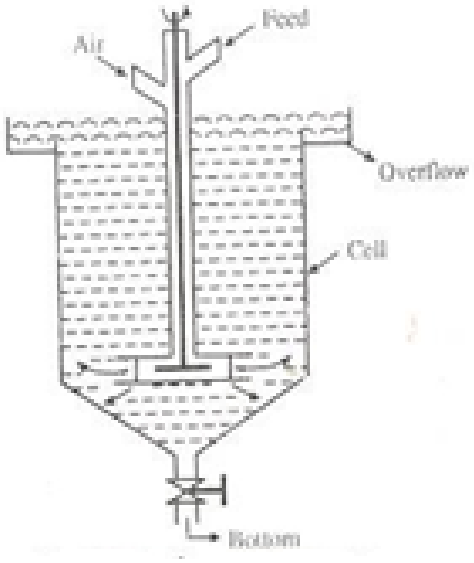
	a) Coarsest trommel first b) Finest trommel first c) Single trommel with different perforations d) Concentric trommels with coarsest perforations inside	
3-e	**Constant rate and constant pressure filtration:** The method of filtration in which the pressure drop over the filter is held constant throughout the run so that the rate of filtration is maximum at the start of filtration and decreases continuously towards the end of the run is called Constant pressure filtration. In case of constant pressure filtration, application of high pressure results in a low rate of filtration as the first particles filtered will be compacted into a tight mass that largely fills the pores of filter cloth. The filtration in which the pressure drop is varied usually from minimum at the start of filtration to a maximum at the end of filtration so that the rate of filtration is constant throughout the run is called constantrate filtration. In case of constant rate filtration,as the maximum pressure is reached towards the end of therun,the whole cycle is operated at less than the maximum capacity.Practically filtration is carried out at constant rate until the inlet pressure reaches a specifiedmaximum & then it is continued atconstant pressure until the end of run.	2 2
3-f	**Electrostatic separator:** **Diagram**	

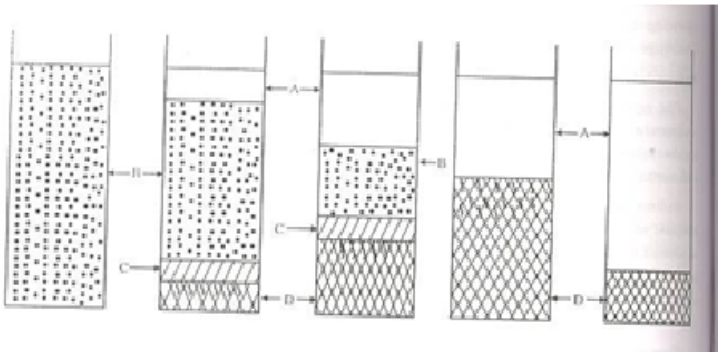
	 **Working:** The solid particles are fed to a drum from hopper. Conductive particles assume the potential of drum, opposite to that of active electrode, hence attracted towards active electrode. Non-conductive particles get repelled by electrode, attracted by drum, falls straight in collecting bin due to gravity.	2 2
4	**Attempt any FOUR of the following**	**16**
4-a	**Classification of size reduction equipment:** 1. Crushers: Eg. a. Jaw crusher b. Gyratory crusher c. Crushing rolls 2) Grinders Eg. a) Hammer mills;impactors b)Rolling-compression mills i) Bowl millsii)Rolling mills c)Attrition mills d) Revolving mills	1 mark each

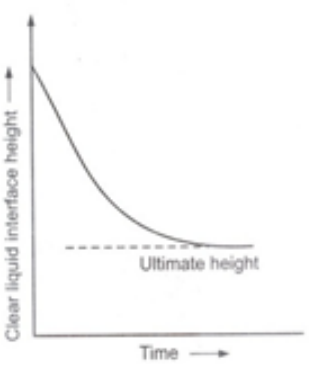
	i) Rod mills ii)Ball mill, Pebble millsiii)Tube mill 3)Ultrafine Grinders Eg. a) Hammer mill with internal classification b) Fluid energy mills c) Agitated mills 4)Cutting machines a) Knife cutters,Dicers,Slitters	
4-b	**Ribbon blender:** **Construction:** It consists of a horizontal semi cylindrical trough having a central shaft & a helical ribbon agitator. Two counteracting ribbons are mounted on same shaft. One of the ribbons moves the solids slowly in one direction, while the other moves the solids in other direction .Mixing takes place due to turbulence generated by counteracting ribbons. For light duty, the trough is open or lightly covered, while for operation under pressure or vacuum, the trough is closed and heavy walled. **Working:**  In batch operated ribbon blenders, the solids are charged and mix until satisfactory & discharged from the bottom. In case of continuously operated units, solids are fed from one end of the trough & discharged from other end. In the path from feed to discharge end, the solids are mixed.	2 2

4-c	**Factors affecting the rate of filtration:** 1) Viscosity of filtrate: Rate of filtration is inversely proportional to viscosity of filtrate. 2) Area of filter medium: Rate of filtration is directly proportional to area of filter surface. 3) Porosity of cake: Porosity of cake increases the rate of filtration. 4) Pressure drop across the filter medium: If pressure drop across the feed inlet & far side of the filter medium is more, filtration rate is more. 5) Resistance of cake: As resistance of cake increases, rate of filtration decreases. 6) Resistance of filter medium: As resistance of cake increases, rate of filtration decreases.	1 mark each for any 4 points
4-d	**Working of cyclone separator:**  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.	4
4-e	**Bottom driven batch centrifuge:** **Principle:** A centrifuge is any rotating machine in which centrifugal force is	1

	utilized for separation of solids from liquids. **Working:** Slurry is fed to rotating basket through an inlet pipe, forced against basket sides by centrifugal force.The liquid passes through filter medium into casing and out a discharge pipe, while solids form a filter cake (thickness 50 to 150 mm). Cake is washed by spraying wash liquid to remove soluble material. Then cake is spun to dryness at higher speed, motor is turned off and basket speed is reduced by a brake. At the basket speed of 30 to 50 rpm , cake is discharged by cutting it by unloader knife. The knife peels the cake and drops in basket floor.  	3
4-f	*Given data* x_F= *0.635* x_D = 0.945 x_B = 0.285 i)Ratio of Overflow to feed – ——— = ———	1

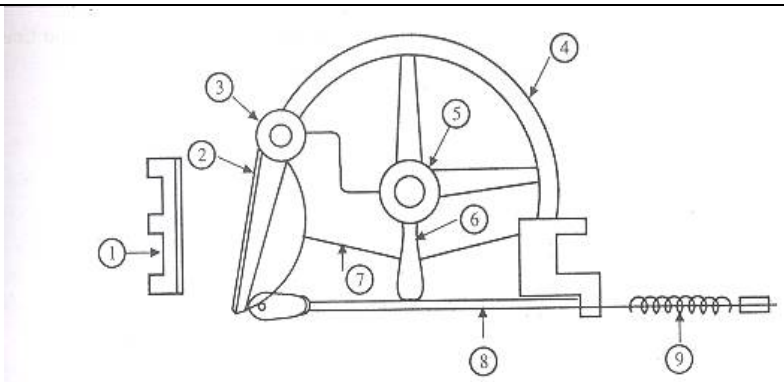
	ii)Ratio of underflow to feed $\frac{B}{F} = \frac{(x_D - x_F)}{(x_D - x_B)} = \frac{(0.945 - 0.635)}{(0.945 - 0.285)} = \mathbf{0.4696}$ iii) Overall effectiveness of screen $E = \frac{(x_F - x_B)(x_D - x_F)x_{D(1-x_B)}}{(x_D - x_B)^2(1 - x_F)x_F}$ $E = \frac{(0.635-0.285)(0.945-0.635)0.945(1-0.285)}{(0.945-0.635)^2(1-0.635)0.635} = .7251 = \mathbf{72.51\%}$	1 2
5	**Attempt any TWO of the following**	**16**
5-a	**Froth flotation:** **Definition:** Floatation refers to an operation in which one solid is separated from another by floating one of them at or on the liquid surfaces. Separation of a mixture of solids using Froth flotation methods depends on the difference in surface properties of the materials involved. **Diagram:**  	2 2

	Construction: 1.The mechanically agitated cell consists of a tank having square or circular cross-section. 2.It is provided with an agitator which violently agitates the pulp. 3.The air from a compressor is introduced into the system through a downpipe surrounding the impeller shaft. 4.The bottom of the tank is conical and is provided with a discharge for tailing. 5. An overflow is provided at the top for mineralized froth removal. **Working:** 1. Water is taken into the cell; material is feed to the cell. 2. The promoters and frothers are added. 3. Agitations are given and air is bubbled in the form of fine bubbles. 4. Air-avid particles due to reduction in their effective density, will rise to the surface and be held in the froth before they are discharged from the overflow 5. Hydrophilic particles will sink to the bottom and removed from the discharge for tailing	2 2
5-b	**Laboratory batch sedimentation test:**  1.The mechanism of settling may be described by batch settling test in glass cylinder in laboratory.	2

	2. As shown in figure, cylinder containing newly prepared slurry of a uniform concentration of uniform solid particles through out. 3. As soon as the process starts, all the particles begin to settle and are believed to approach rapidly terminal settling velocities under hindered settling condition 4. Various zones of concentration then are established. The heavier faster settling particles settled at the bottom of glass cylinder are indicated by Zone D. 5.Above zone D forms another layer, called zone C,a region of variable size distribution and non- uniform concentration. 6.The boundary between C and D is usually obscure and is marked by vertical channels through which fluid is rising from the lower zone D as it compresses. 7. Above zone C is zone B, which is a zone of uniform concentration of approximately the same concentration as that of original pulp. 8. Above the zone B is zone A, which is a zone of clear liquid. if original slurry is closed sized with respect to smallest particles, the boundary between A and B is sharp.	2
	Graph  When the experimental data of height of interface v/s time are plotted, we get the curve .The slope of this curve at any point of time represents the settling velocity of	2 2

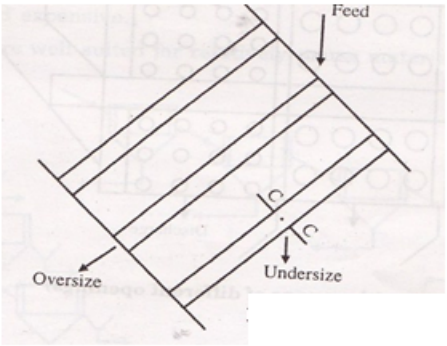
	suspension at that instant. During the early stage of settling process, the rate of settling is constant, as shown by the first portion of the curve. As time increases, the settling velocity decreases and steadily drops until the ultimate height is reached.	
5-c	**Data:** Diameter of ball mill = 800 mm = 0.8 m Diameter of ball = 60 mm = 0.06 m Cririca l speed of ball mill (Nc) $Nc = \frac{1}{2\pi}\sqrt{\frac{g}{R-r}}$ $g = 9.81\ m/s^2$ R= 800/2 = 400 mm = 0.40 m r = 60/2 = 30 mm = 0.03 m $Nc = \frac{1}{2\pi}\sqrt{\frac{9.81}{0.40 - 0.03}}$ Nc = 0.82 r.p.s. (a) Operating speed is 55 % of critical speed. 55% of the critical speed = 0.55 X 0.82 = 0.45 r.p.s. **Operating speed = 0.45r.p.s.** (b) Operating speed is 40 % more than the critical speed. Critical speed = 1.40 X (Operating Speed) **Operating speed = 0.82 /1.40 = 0.586r.p.s.**	1 1 2 2 2
6	**Attempt any FOUR of the following**	**16**
6-a	**Vortexing:** If low viscosity liquid is stirred in an unbaffled tank by centrally mounted agitator, there is a tendency for nearly pure rotary flow pattern to be developed and lighter liquid,ie air is usually drawn in to form a vortex and the degree of agitation is very much reduced. This phenomenon which takes place in an unbaffled tank regardless	2

	of the type of impeller isknown as vortexing. **Methods to avoid vortexing:** There are four methods of prevention of swirling and vortex formation a. Off-center mounting of the impeller. b. Use of Baffles c. Use of diffuser ring with turbines d. Angular entry of agitators.	2
6-b	**Cake filtration and deep bed filtration:** In the Case of cake filtration, the proportion of solids in suspension is large and most of the solid particles are collected in the cake which can subsequently be detached from a filter medium. In cake filtration, during the initial period of flow, solid particles are trapped within the pores of a medium forming the true filter medium. The liquid passes through the bed of solids and through the filter medium. In the early stage of filtration, the rate of filtration is high. **Deep Bed Filtration:** In the case of deep bed filtration, the portion of solids is very small and the particles of the solids being smaller than the pores of a filter medium will penetrate a considerable depth and ultimately get trapped inside the filter medium and usually no layer of solids will appear on the surface of the medium.	2 2
6-c	**Diagram of jaw crusher:**	2 marks for diagram and 2 marks for labeling



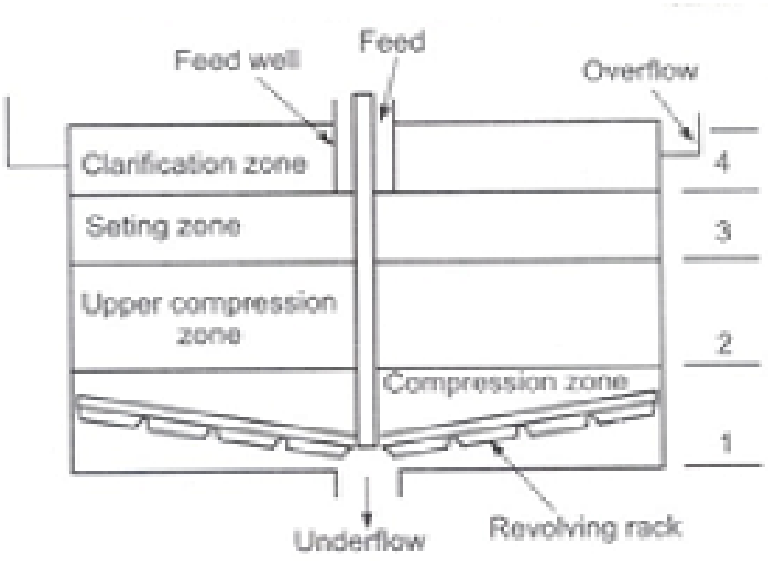
(1) Fixed jaw, (2) Movable jaw, (3) Shaft, (4) Fly wheel, (5) Eccentric, (6) Pitman, (7) Toggle, (8) Tie rod, (9) Spring

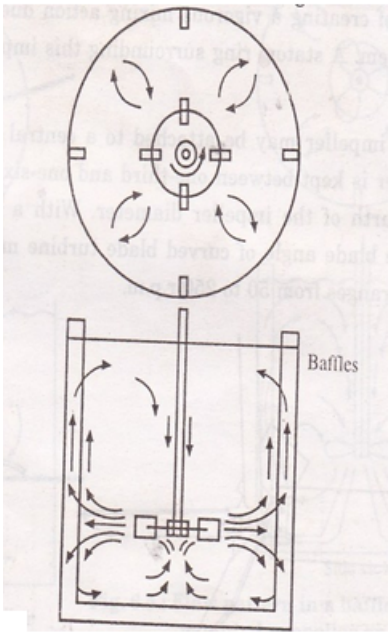
6-d **Working of grizzly screens:** 4



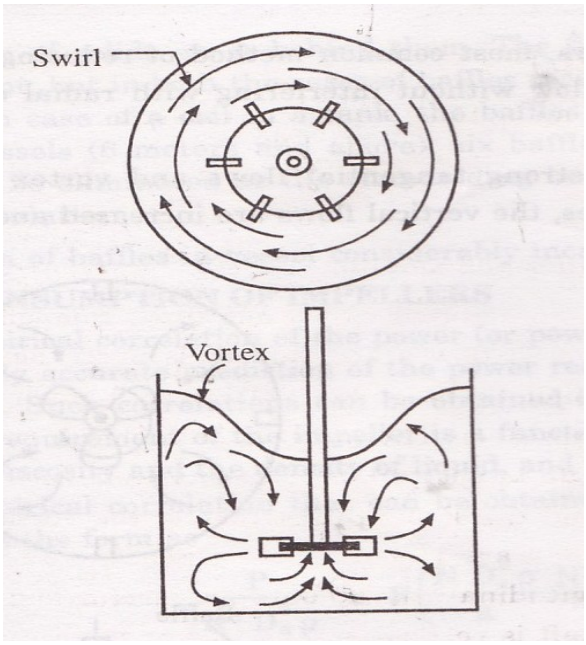
1) A coarse feed is fed at the upper end of the grizzly.Large chunks roll and slide to the lower end while small lumps having size less than the opening in bars fall through the grid into a separate collector.
2) If the angle of inclination to the horizontal is greater, better is the output but lower the efficiency.

6-e **Terminal settling velocity:**Under free settling condition as the particle falls its velocity increases and will continue to increases until the resisting force and accelerating force are equal.Whenthis point is reached,theparticle will settle at definite constant velocity during remainder of its fall.This ultimate constant velocity 2

	is called Terminal velocity **Diagram of continuous thickener:**  	2
6-f	**Diagram of flow patterns in baffled and un baffled tanks** **Flow pattern in baffled tank**	2



Flow pattern in unbaffled tank



2