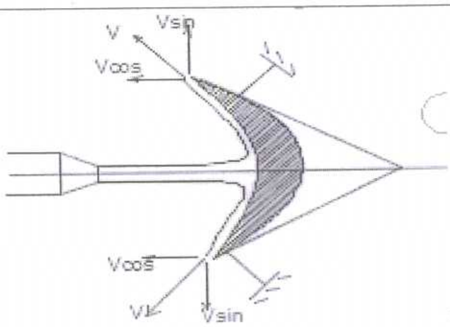
SCHEME OF VALUATION

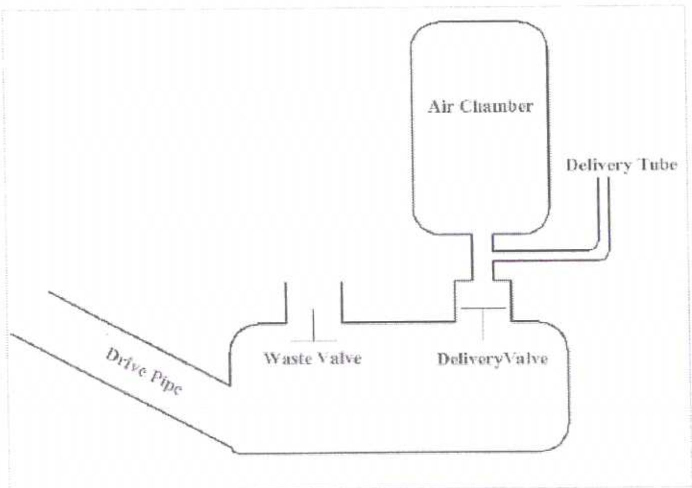
(Scoring Indicators)

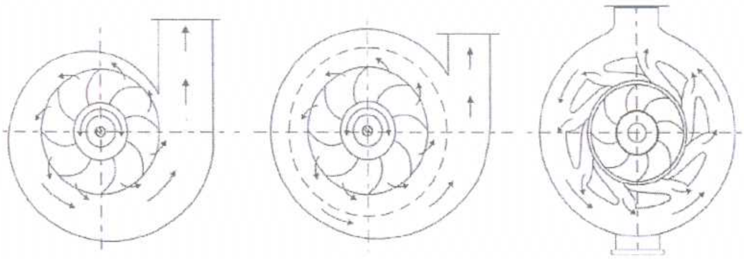
COURSE CODE & TITLE (15) 6022 HYDRAULIC MACHINES

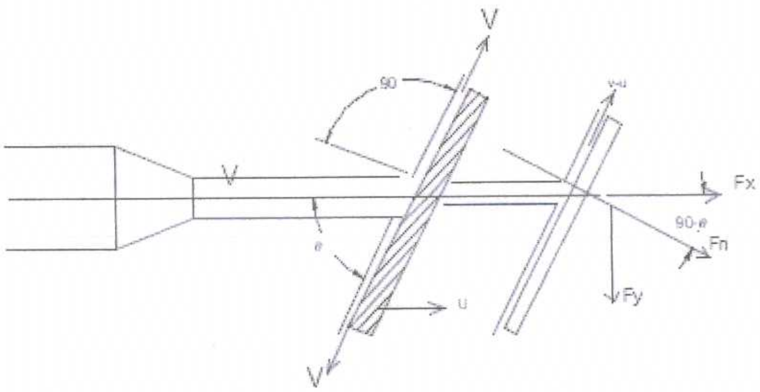
Qst. No	Scoring Indicator	Split up score	Sub total	TOTAL
	PART - A			
1	**Jet propulsion** is the propulsion of an object in one direction, produced by ejecting a jet of fluid in the opposite direction. By Newton's third law, the moving body is propelled in the opposite direction to the jet	2	2	10
2	When the jet of water is completely closed by pushing the spear in forward direction than the amount of water striking the runner becomes zero. But still the runner keeps moving due to the inertia of the runner. In order to stop the runner in the shortest possible time a small nozzle is provided which directs the jet of water at the back of the vanes. This jet of water used to stop the runner of the turbine is called breaking jet.	2	2	
3	Centrifugal governor	2	2	
4	This draft tube at the end of the turbine increases the pressure of the exiting fluid at the expense of its velocity. This means that the turbine can reduce pressure to a higher extent without fear of back flow from the tail race	2	2	
5	NPSH – (net positive suction head)-	2	2	

PART - II				
1	 V=velocity of jet a-area of cross section of jet = density of water m= mass flow rate per second=ρav components of velocity of jet in the direction of jet= -v cosθ(opposite) components of velocity of jet perpendicular to the direction of jet= v sinθ plate is smooth, no loss of energy, initial velocity=final velocity applying impulse momentum equation in normal direction of plate Force exerted in the direction of jet F_x=change in momentum=mass of water/sec X change in velocity =ρav(v - -v cosθ)= $\rho av^2(1+\cos\theta)$ F_x= ρav(0 - v sinθ)= -$\rho av^2\sin\theta$	3+3	6	
2	Actual velocity= $C_v.\sqrt{2gh}$= $0.97X\sqrt{(2X9.81X30)}$= 23.53m/s F_x= ρav^2=1000xax23.53^2=1250 a=$2.25X10^{-3}$ mm^2 a=$\frac{\pi}{4}d^2$, d=$(4.a/\pi)^{1/2}$=0.0536m=53.5mm	2 2 2	6	
3	▪ It is a renewable energy source. Water energy can be used again and again. ▪ The running cost of turbine is less compare to other. ▪ It can be control fully. The gate of dam is closed			

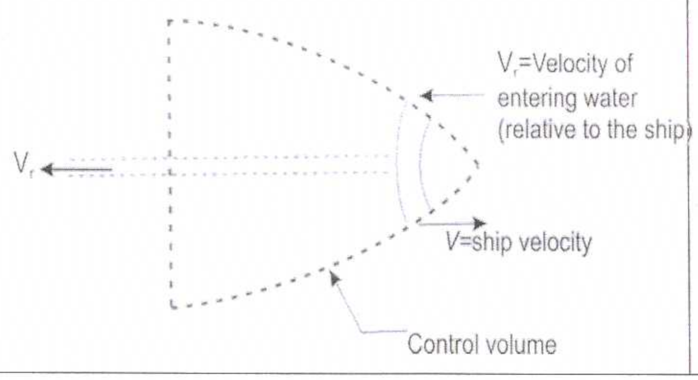
	when we does not need electricity and can be open when we needed. ▪ Dams are used from very long time so it can be used for power generation. ▪ It does not pollute environment. ▪ It is easy to maintain. ▪ The dam constructed for hydraulic turbine can become a tourist place. ▪ This turbine having a high efficiency. ▪ Since Dams are used. So it is used for power generation. ▪ This is easy to maintain.	1x6 6	6	
4	. Power,p=ρgQH Density of waterρ=1000kg/m^3 P=1000x9.81x1x150=1471k.w Specific speed $N_s = \frac{N\sqrt{P}}{H5/4}$ $=\frac{300.\sqrt{1471}}{(150)5/4}$=21.91	2 2 2	6	30
5	**Impulse Turbine** | **Reaction Turbine**	Any six=6	6	
	1. In impulse tur ine only kinetic energy is used to rotate the turbine. | 1. In reaction turbine both kinetic and pressure energy is used to rotate the turbine.			
	2. In this turbine water flow through the nozzle and strike the blades of turbine. | 2. In this turbine water is guided by the guide blades to flow over the turbine.			
	3. All pressure energy of water converted into kinetic energy before striking the vanes. | 3. In reaction turbine, there is no change in pressure energy of water before striking.			
	4. The pressure of the water remains unchanged and is equal to atmospheric pressure during process. | 4. The pressure of water is reducing after passing through vanes.			
	5. Water may admitted over a part of circumference or over the whole circumference of the wheel | 5. Water may admitted over a part of circumference or over the whole circumference of the			

	of turbine.	wheel of turbine.			
	6. In impulse turbine casing has no hydraulic function to perform because the jet is at atmospheric pressure. This casing serves only to prevent splashing of water.	6. Casing is absolutely necessary because the pressure at inlet of the turbine is much higher than the pressure at outlet. It is sealed from atmospheric pressure.			
	7. This turbine is most suitable for large head and lower flow rate. Pelton wheel is the example of this turbine.	7. This turbine is best suited for higher flow rate and lower head situation.			
6	 The hydraulic Ram is a complete automatic device that uses the energy in the flowing water such as spring, stream or river to pump part of the water to a height above that of the source. With a continuous flow of water a ram operates continuously with no external energy source. The pump uses the **momentum** of a relatively large amount of moving water to pump a relatively small amount of water uphill A ram is a structurally simple unit consisting of two moving parts. These are the impulse valve (or waste valve) and the delivery (check) valve. The unit also consists of an air chamber and an air valve. The operation of a ram is		3+3	6	

	intermittent due to the cyclic opening and cloning of the waste and delivery values. The closure of the waste valve creates a high pressure rise in the drive pipe. An air chamber is required to transform the high intermittent pumped flows into a continuous stream of flow. The air valves allow air into the ram to replace the air absorbed by the water due to the high pressure and mixing in the air chamber			
7	 Volute Casing Vortex Casing Diffuser Ring Casing Types of Centrifugal Pumps (According to the Type of the Casing) 1.Volute casing 2. Vortex casing 3. Casing with guide blades **1. Volute casing:**It is a spiral type in which area of flow increase gradually. The increase in area of flow decreases the velocity of flow. Decrease in velocity increases pressure of water flowing through the casing. **2. Vortex casing:**-If a circular chamber is introduced between the casing and impeller then this is called as vortex casing. Due to introduction of circular chamber eddy loss reduced considerably. **3. Casing with guide blades:**-In this type of casing impeller is surrounded by a number of guide blades which are act like diffusers hence increase the pressure at outlet.	3+3	6	
	PART - C			
III (a)	a= area of jet ,V=velocity of jet ,u= velocity of plate Relative velocity of jet of fluid w.r.to the plate in the	4+fig3		

	direction of jet=(v-u)=velocity of jet strikes on the plate Mass of fluid striking per second=ρa(v-u) Plate is smooth no loss of energy due to impact of jet and the jet leaves the plate tangentially so leaving jet velocity=0 Force by jet in the direction normal to the plate=mass of water/sec X change in velocity Fn= $\rho a(v-u)\,[(v-u)\sin\theta - 0] = \rho a(v-u)^2 \sin\theta$ Normal force can be resolved in to the direction of jet Fx= $\rho a(v-u)^2 \sin\theta . \sin\theta = \rho a(v-u)^2 \sin^2\theta$ Work done per sec or power=Fx . velocity of plate Power= $\rho a(v-u)^2 \sin^2\theta . u$ watts  		7	
(b)	Angle made by relative velocity at the out let of the plate=180-θ=180-160=20°			
	i)Thrust in the direction of jet, Fx= $\rho a(v-u)^2 (1+\cos\theta)$ $=1000 x 1.256 x 10^{-03} x (20-10)^2 (1+\cos 20) = 243.62$N	3		
	ii)Work done/sec= Fx . u=243.62x10=2436.2Watt	2		
	iii)Efficiency= $\frac{\text{work done/sec}}{\text{Energy supplied/sec}}$x100% energy supplied/sec= $0.5\rho av^3$= $0.5 x 1000 x 1.256 x 10^{-03} x 20^3 = 5024$ Watt η=2436.2/5024x100=48.49%	3	8	

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IV
(a)</td><td>A water jet generates propulsive thrust from the reaction created when water is forced in a rear ward direction. It works in relation to Newton's Third Law of Motion - "every action has an equal and opposite reaction. In a boat hull the jet unit is mounted inboard in the aft section. Water enters the jet unit intake on the bottom of the boat, at boat speed, and is accelerated through the jet unit and discharged through the transom at a high velocity. A jet of water which is discharged at the back (back called stern) of the ship, exerts a propulsive force on the ship.The ship carries centrifugal pumps which draw water from the surrounding sea. This water is discharged through the orifice provided at the back of the ship in the form of a jet. The reaction of the jet coming out at the back of the ship propels the ship in the opposite direction of the jet. The water from the surrounding sea by the centrifugal pump is taken by the following two ways:-1) Through inlet orifices which are at right angles to the direction of the motion of the ship and2) Through the inlet orifices, which are facing the direction of motion of the ship.


</td><td>Explan ation=4
Fig=3</td><td>7</td><td></td></tr>
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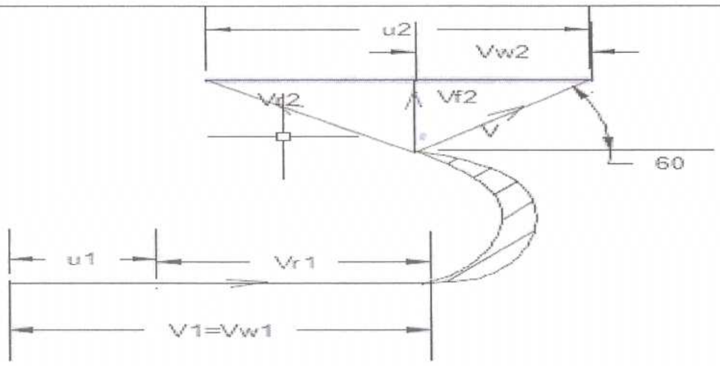
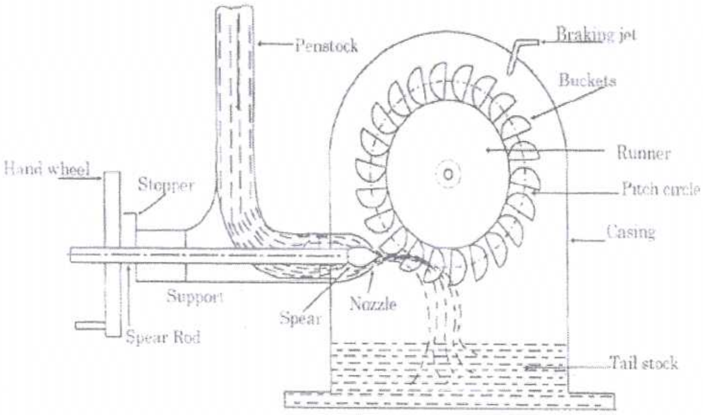
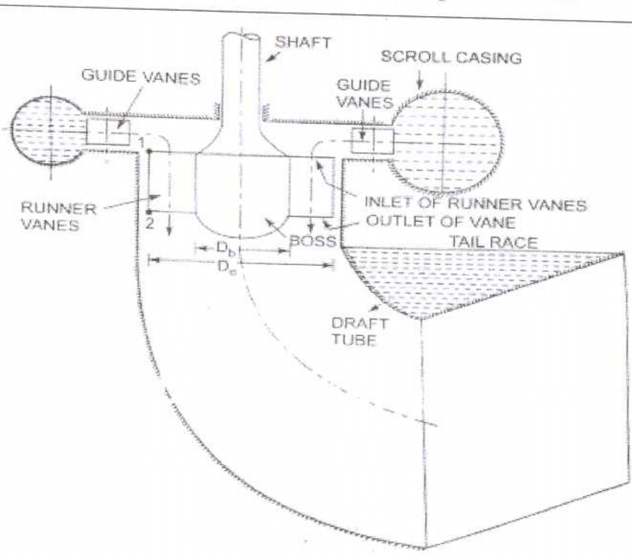
(b)	 Area of jet= $\frac{\pi}{4}d^2$ = 0.05^2 =0.00196m^2 , velocity of jet V=20m/sec ,vane velocity $u=u_1=u_2$=10m/s, Angle made by the leaving jet in the direction of jet=60°,β=180-60=120° $Vr_1=Vr_2$=V-u= 20-10=10m/s,$V_1=Vw_1$=20m/s $< ABC$=180-(60+ϕ)=120-ϕ , Apply sin rule in out let triangle(Vr_2/sin60)=(2/sin(120-ϕ))=10/sin60=10/ sin(120-ϕ),gives $\phi=60^0$, $Vw_2=u_2-Vr_2$Cos60=5m/s Force exerted Fx= ρav [Vw_1 - Vw_2] =1000x0.00196x10x(20-5)=294N Work done/sec,P=Fx.U=294x10=2940W	Fig=2 ϕ=2 Vw_2=1 Fx=2 P=1	8	
V(a)	**<u>1) Based on type of energy at inlet to the turbine:</u>** ▪ **Impulse Turbine** : The energy is in the form of kinetic form. e.g: Pelton wheel, **Reaction Turbine** : The energy is in both Kinetic and Pressure form. e.g: Propeller, Francis turbine. **<u>2) Based on direction of flow of water through the runner:</u>** ▪ **Tangential flow:** water flows in a direction tangential to path of rotational directions. ▪ **Radial flow** Water flows radial to the axis of the turbine. ▪ **Axial flow :** Water flows parallel to the axis of the turbine	Any five		

	▪ **Mixed flow :** Water enters radially at outer periphery and leaves axially. E ▪ **<u>3) Based on the head under which turbine works:</u>** ▪ High head, impulse turbine. e.g : Pelton turbine. ▪ Medium head,reaction turbine. e.g : Francis turbine. ▪ Low head, reaction turbine. e.g : Kaplan turbine, propeller turbine. **<u>4) Based on the specific speed of the turbine:</u>** ▪ Low specific speed, impulse turbine. e.g : Pelton wheel. ▪ Medium specific speed, reaction turbine. e.g : Francis wheel. ▪ High specific speed, reaction turbine. e.g : Kaplan and Propeller turbine. **<u>5) Based on the name of the originator:</u>** ▪ Impulse turbine – Pelton wheel. ▪ Reaction turbine, Francis, , kalpan, **<u>6) Based on the disposition of shaft:</u>** ▪ Horizontal turbine – ▪ Vertical turbine.	7	7	
(b)	Overall efficiency,$\eta_o = \frac{P}{wQH}$ - $Q = \frac{P}{w.H.\eta o} = \frac{8000000}{9810x940x0.85}$ =1.02m^3/s Dia of jet,d=$0.54(\frac{Q}{\sqrt{H}})^{0.5}$=$0.5(\frac{1.02}{\sqrt{940}})^{0.5}$=0.0985m=98.5mm ii) peripheral velocity of wheel ,u $=Ku.\sqrt{2}.g.H$ $=0.46.\sqrt{2}x9.81x940$=62. 47m/s peripheral velocity of wheel ,u $\frac{\pi DN}{60}$ $, D =$	2 2		

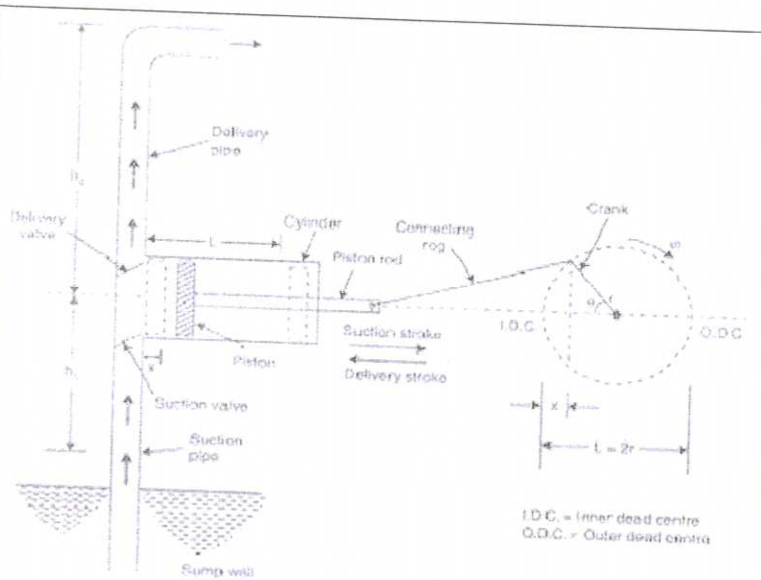
	$\frac{60x62.47}{\pi x600}$=1.99m Jet ratio=D/d=1.99/0.0985=20.2 No of buckets, Z=0.5D/d+15=0.51.99/0.0985+15=25Nos	2 2	8	
VI (a)	Flow rate,Q= $\frac{P}{\eta wH}$ = $\frac{1000000}{0.85x9810x50}$ =2.3985 m^3/s Velocity of jet $V_1=Cv\sqrt{2}.g.H$= $0.98\sqrt{2}.g.50$= 30.694m/s Discharge through each jet ,q=Q/n=2.3985/2=1.19925 m^3/s q =($\frac{3.14\,d2}{4}$) V ;d= ($\frac{1.19925x4}{30.694x3.14}$)$^{0.5}$=0.223m diua of jet ,d=223mm	2 1 2 2	7	
(b)	 The Pelton wheel or Pelton wheel turbine is a tangential flow impulse turbine used for high heads of water. The Scientist who named Pelton wheel turbine is L A Pelton, an American Engineer. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric pressure. Nozzle:The amount of water striking the buckets of the runner is controlled by providing a spear in the nozzle. The speed is a conical needle which is operated either by a hand wheel or automatically in an axial direction depending	3+5	8	

	upon the size of the unit. When the spear is pushed forward into the nozzle and the amount of water striking the runner is reduced. 2. Runner and buckets:The runner or blade consists of a circular disc on the Periphery of which a number of buckets evenly spaced are fixed. The Shape of the bucket is of double hemispherical cup or bowl. Each bucket is divided into two symmetrical parts by a dividing wall which is known as a splitter.The jet of water strikes on the splitter. The splitter divides the jet into two equal parts and the Jets comes out at the outer edge of the bucket. Casing:The function of the casing is to prevent the splashing of the water and to discharge water to tailrace. It also acts as a safe ground against accidents. It does not perform any hydraulic function. Breaking jet:When the nozzle is completely closed by moving the spear in the forward direction, the amount of water striking the runner reduces to zero. But the runner due to inertia goes on revolving for a long time. To stop the runner in a short time, a small nozzle is provided which directs the jet of water on the back of the vanes. This jet of water is called breaking jet. Working of Pelton Wheel Turbine: The water is stored at high head reaches the nozzle of the Pelton turbine. The nozzle increases the kinetic energy of the water and directs the water in the form of the jet.Now, The jet of water from the nozzle strikes the buckets (vanes) of the runner. So that the runner rotates at very high speed and the quantity of water striking the vanes or buckets is controlled by the spear present inside the nozzle			

VII (a)	Power available,P = $\eta_o wQH$ = 0.85x9810x250x25= 52115625w=52115.6kW Specific speed of turbine,Ns=$\frac{N\sqrt{P}}{H^{5/4}}$ Power available from a single Francis turbine,P=$\frac{Nsf_{H.5/4}}{N}$ $\frac{300x25^{5/4}}{250}$=4500 kW No of francis turbines=52115.6/4500=11.58 say=12Nos Power available from a single Kaplan turbine,P=$\frac{Nsf_{H.5/4}}{N}$ $\frac{350x25^{5/4}}{250}$= 6125 kW No of francis turbines=52115.6/6125=8.508 say=9Nos		2 2.5 2.5	7	
(b)	Francis turbine is radial flow turbine but in case of modern Francis turbine water enters radially and leaves the turbine axially which is called as mixed flow turbine.	Kaplan turbine is axial flow turbine i.e. water enters and leaves the turbine runner both in axial direction.	1x8	8	
	Efficiency of Francis turbine is less as compare to Kaplan turbine	Efficiency of Kaplan turbine is higher than Francis turbine			
	Friction losses are higher	Less friction losses as compare to Francis turbine			
	The size of Francis turbine is quite large as compare to Kaplan turbine	Kaplan turbine compact in cross sectional area			
	Large number of vanes in runner, generally the number of vanes are 16 to 24	Kaplan turbine is compact in size so the numbers of vanes are also less; generally the number of vanes is 4 to 8.			
	The direction of shaft is may be vertical or	The direction of shaft is always in vertical direction			

	horizontal as per requirement.	because it is axial flow turbine.			
	Francis turbine requires medium range of water head i.e. it generally varies from 100-600 meters	Kaplan turbine works on very low head, the requirement of head is generally 100 meters.			
	As it is works in medium head therefore it requires medium flow rate.	Kaplan turbine requires high flow rate of water.			
	Francis turbine works on medium range of specific speed i.e. the specific speed varies from 60 to 300.	Kaplan turbine requires high value of specific speed because it is works on low head. Generally th e range of specific speed varies from 600-1000.			
	Fancies turbine has simple governing mechanism.	The governing mechanism of Kaplan turbine is quite complicated in construction and working.			
	Francis turbine has fixed runner vanes on the shaft	Kaplan turbines vanes are adjustable i.e. we can easily adjust the runner vanes as per our requirements.			
VIII (a)	 Main components of Kaplan turbine.		Fig-3	7	

	Kaplan Turbine is an axial flow reaction turbine with adjustable blades. This turbine was developed 1913 by Viktor Kaplan, who was a Austrian Professor. It is capable of working at low head and high flow rates . The reaction force of leaving water is used to turn the runner of the Kaplan turbine, As the water flows through the twisted blades a lift force is generated in the opposite direction of the leaving water and that lift force causes the blades to rotate. **<u>Scroll Casing</u>**:It is a spiral type of casing that has decreasing cross section area. The water from the penstocks enters the scroll casing and then moves to the guide vanes where the water turns through 90° and flows axially through the runner. It protects the runner, runner blades guide vanes and other internal parts of the turbine from an external damage. **<u>Guide Vane Mechanism;</u>**It is the only controlling part of the whole turbine, which opens and closes depending upon the demand of power requirement. In case of more power output requirements, it opens wider to allow more water to hit the blades of the rotor **<u>Draft Tube;</u>**The pressure at the exit of the runner of Reaction Turbine is generally less than atmospheric pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of turbine to the tail race. This tube of increasing area is called Draft Tube. One end of the tube is connected to the outlet of runner while the other end is sub-merged below the level of water in the tail-race.	Expl-4		

	Runner Blades; The heart of the component in kaplan turbine are its runner blades, as it the rotating part which helps in production of electricity.Its shaft is connected to the shaft of the generator. The runner of the this turbine has a large boss on which its blades are attached and the the blades of the runner is adjustable to an optimum angle of attack for maximum power output. The blades of the Kaplan turbine has twist along its length.			
VIII (b	Overall efficiency, η_o=SP/WP=SP/ γQH Q=12X10^6/9810x20x0.84=72.81m^3/s Q= $\frac{3.14}{4}$(Do^2-Db^2)Vf Vf=4x72.81/(3.14(3.6^2-1.8^2)=9.54m/s tan $\propto$ =Vf$_l$/Vw$_l$ Vw$_l$= Vf$_l$/tan35=13.62m/s Hydraulic efficiency , η_h= Vw$_l$.u$_l$/gH U$_l$=9.81x20x0.88/13.62=12.67m/s U1 =3.14x DxN/60 N=67.28 r.p.m	2 2 1 2 1	8	
IX (a)	 When the power source is connected to crank, the crank	Fig-4		

	will start rotating and connecting rod also displaced along with crank. The piston connected to the connecting rod will move in linear direction. If crank moves outwards then the piston moves towards its right and create vacuum in the cylinder. This vacuum causes suction valve to open and liquid from the source is forcibly sucked by the suction pipe into the cylinder. When the crank moves inwards or towards the cylinder, the piston will move towards its left and compresses the liquid in the cylinder. Now, the pressure makes the delivery valve to open and liquid will discharge through delivery pipe. When piston reaches its extreme left position whole liquid present in the cylinder is delivered through delivery valve. Then again the crank rotate outwards and piston moves right to create suction and the whole process is repeated.	Exp-4	8	
(b)	Specific speed Ns=$\frac{N\sqrt{Q}}{H3/4}$ Head of water per stage,H= $[\frac{N\sqrt{Q}}{Ns}]^{4/3}$=$[(1500x\sqrt{01})/20]^{4/3}$ =68.17m No of stages=total head of water/head of water in each stage=500/68.17=7.33 Say 8 stages	4 3	7	
X(a)	**Centrifugal pump** | **Reciprocating pump** It is one of the rotary pumps which used kinetic energy of impeller. | It is a positive displacement type pump which is forced by piston.	Any eight 1x8		

	It is one of the rotary pumps which used kinetic energy of impeller.	It does not discharge the fluid continuously.	8
	It continuously discharges the fluid.	The pressure does not affect flow rate in reciprocating pumps.	
	In centrifugal pump the flow rate decreases which increasing the pressure.	It is used for pump low viscous fluid.	
	It is used for pumping high viscous fluid.	In reciprocating pump viscosity of fluid does not affect the discharge rate.	
	In this pumps discharge is inversely promotional to the viscosity of fluid.	Efficiency is high.	
	Efficiency of these pumps are low compare to reciprocating pump.	It does not have any problem of priming.	
	Centrifugal pump have problem of priming.	It uses piston cylinder device to transfer energy to fluid.	
	It uses impellers to transfer energy to fluid.	These are heavier compare to centrifugal pump.	
	They are lighter than reciprocating pumps.	These gives higher heads at low discharge.	
	It gives higher discharge at low heads.	These are costly.	
	It is less costly.	These required higher maintenance.	
	These pumps required less maintenance.	These pumps are difficult to install. These required more floor area.	
	Centrifugal pumps are easy to install. These required less floor space.	These are mostly used in industries and high viscous fluid pumped at a high	
	It is mostly used for domestic purpose and where higher discharge at low head required.		
(b)	area of piston=$3.14 \times 0.25^2/4 = 0.049\ m^2$		

	Theoretical discharge Qthe=LAN/60=0.3x0.0625x40/60== 0.0.00981m3/s=9.81 litre/s	2		
	Slip= Qthe-Q act= 9.81-8.5= 1.31 litre/sec	1	7	
	% slip = (Qthe-Q act/Q the)x100 = 13.35%	2		
	Power,P=γQH=9810x0.00981x30=2887 watt	2		