IQRA National University, Peshawar
Department of Electrical Engineering
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Power Generation

Name: ______________

*Terminal Examination* *course Instructor: Engr.Sanaullah Ahmad*

***Note: Attempt all Questions & Draw diagrams where necessary.***

***Question No 1*** **20**

A. With the help of a diagram show different Elements of a Hydropower Plant? CLO 1
B. Water for a small hydroelectric station is to be made available from a pondage with a volume of $5 \times 10^5 m^3$ located at a height uphill to provide water at a head of 100m at a hydraulic efficiency of 85% If the electrical efficiency is 94% and the water supply is available for 8 hours daily, determine the capacity of the generator to be installed at the power station. CLO 2

***Question No 2*** **20**

A. Classify different hydropower turbines, what are the parameters required for the selection of hydropower turbines? CLO1
B. Select a suitable turbine for a hydropower scheme with available head height of 190m and rated discharge of 2.2 $m^3/s$ with overall efficiency of 85%? Also determine turbine diameter and jet diameter? Specific speed $Ns = 85.49/(h)^{0.243}$. $Diameter = 38.56\sqrt{h}/n$. *Jet Diameter* $q = (\prod dj^2)Vj/4$ *where* $Vj = \sqrt{2gh}$ CLO 2

***Question No 3*** **10**

Explain different stages of Nuclear Fuel Cycle? CLO 1

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## HyDropower plants - Electricity.

* Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water.

* About 16-18 % of global electricity generation

* Total installed hydropwer capacity is about 630 GW.

* China is the largest hydroelectricity producer. (721 terawatthours.

## Hydropower Types.

* Conventional hydroelectric referring to hydroelectric dams. (Potential Energy)

* Run-of-the-river hydroelectricity with captures the (Kinetic energy) in rives or streams, without the use of dams.

* Small hydro projects are 10 megawatts or less and often have no artificial reservoirs.

* Micro hydro Projects provide a few Kilowatts to a few Kilowatts to isolated homes, village, or small industries.

* Pumped-storage hydroelectricity stores water pumped during periods of low demand to be released for generation when demand is high. 2

Site Consideration for Hydropower plants.

* Two Factor

* Amount of water flow per unit time.

* Vertical Height that water can be made fall (head).

* For Reaction turbines the gross head ho is the vertical distance between the water surface level at the intake and the tailrace. while for impulse turbine it is taken from water intake level to nozzle level.

* Effective head height can be calculated by simply subtracting the head losses along path. Head losses are due to frictions within the system (Pipes, Penstock, tunnels

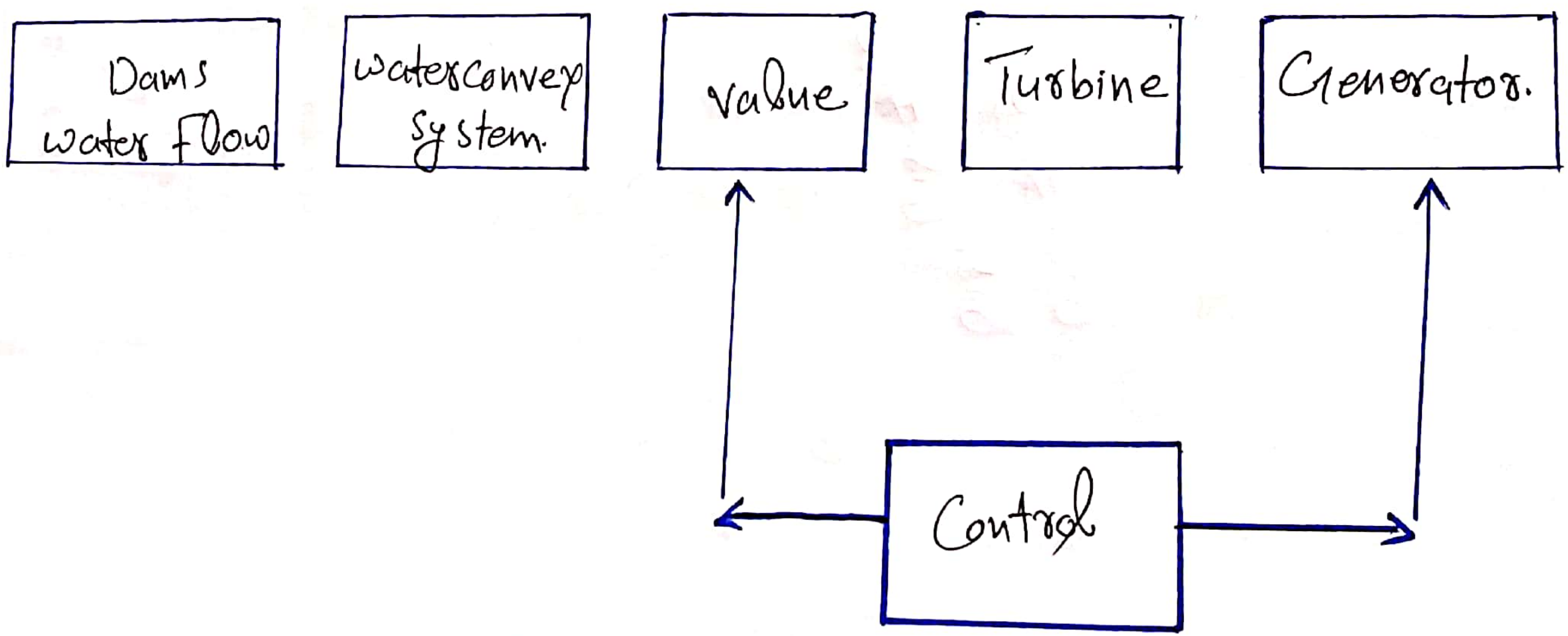
etc.)

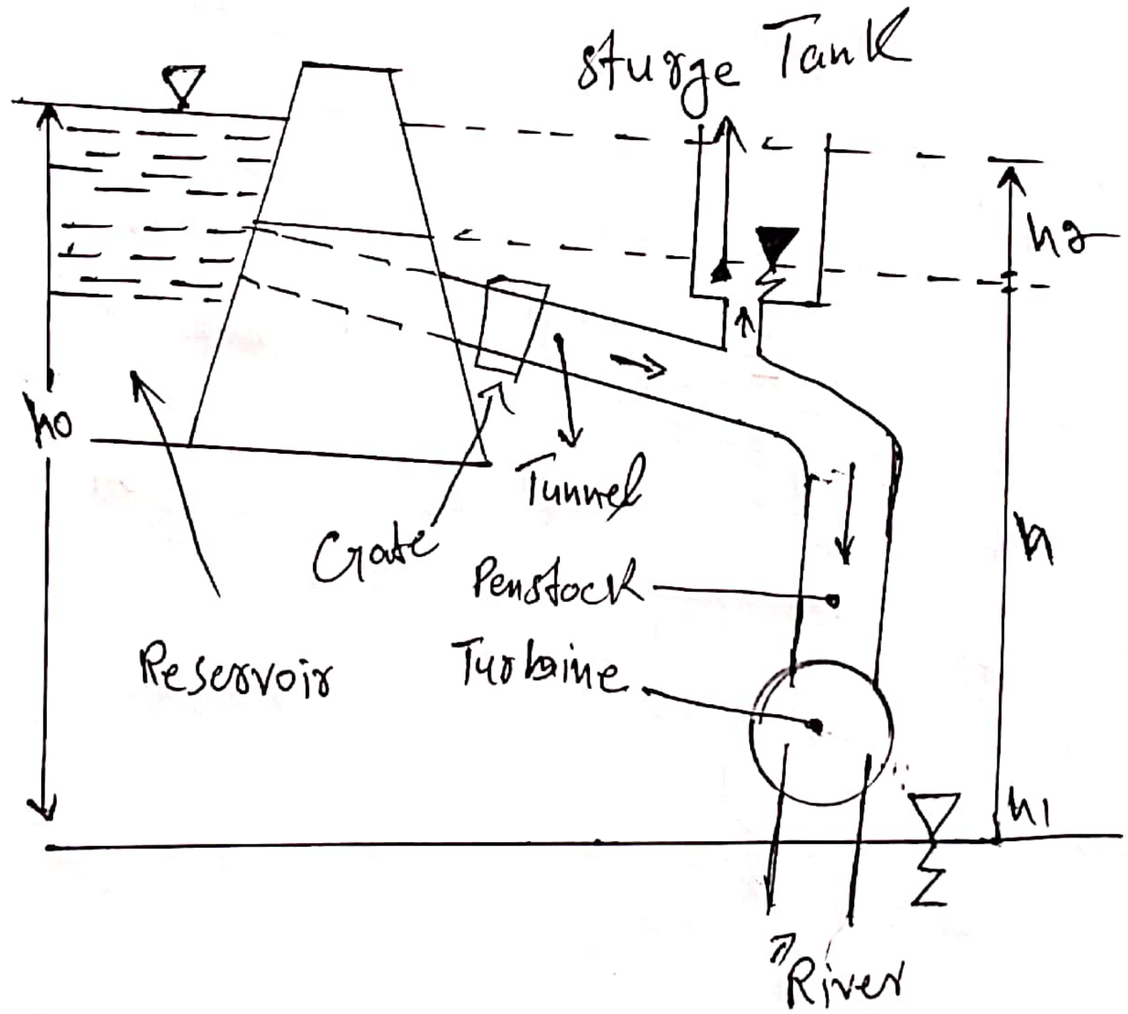
* $H = h_0 - h_2 - h_1$

## Site Considiration.

* Water Sources.
* Hydrology. (preparation of hydrograph, data flow records rain etc.)
* Catchment area (suitable area for lake)
* Geographical Condition. (Fault line)
* Geological Mapping
* Seismic activity.
* strong foundation for dam.

# Hydropower plant General layout






## Element

(i) storage Reservoir
(ii) Dam
(iii) Fore bay
(iv) spilling ways
(v) intake
(vi) surge Tank
(vii) pen stock
(viii) valves
(ix) Gates
(x) Draft tubes
(xi) water Turbines.

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$Q_1$(b).

Given Data.

Efficiency = 88% or 0.88

Avb volume = $V = 5 \times 10^8 m^3$

Avb head = $h = 100m$

electrical efficiency = 98%

overall Efficiency = $0.88 \times 0.98 = 0.80$

using the following formulla.

$E = \eta \rho g h V$

$E = 0.8 \times 1000 \times 9.81 \times 100 \times 5 \times 10^8$

$E = 392000 0 \times 10^8$

$E = 3.92 \times 10^{11}$ W.S

so capacity of head power plant is

$E = 3.92 \times 10^{11}$ W.S. Ans

# Types of hydropower turbines:

1) Impulse Turbine:-
2) Reaction Turbine:-

1) Impulse Turbine of Types:

1) Pelton Turbine
2) Cross-flow Turbine.

## Pelton Turbine

* Pelton wheel

A pelton wheel has one or more free jets, discharging water on the buckets of a runner. Draft tubes are not required for impulse turbine. Since the runner must be located above the maximum tail water to permit operation at atmospheric pressure.

A Turgo wheel resembles a fan blade that is closed on the outer edges. The water stream is applied on one side, goes across the blades and exits on the other side.

## ii Cross-flow Turbine:

It resembles a "Squirrel Cage" blower. The cross-flow turbine allows the water to flow through the blades twice. The first pass is when the water flows from the outside of the blades to the ~~in~~ inside; the second pass is from the inside back out.

A guide vane

at the entrance to the turbine directs the flow to a limited Portion of the runner. The cross-flow was developed to a accommodate larger water flows and lower heads than the Pelton.

2. Reaction Turbine:

* A reaction turbine develops power from the Combined action of Pressure and moving water. The runner is placed directly in the water stream flowing over the blades rather than striking each individually.

* Reaction turbines are generally used for sites with lower head and higher flower than compared with the impulse turbines.

# Types of Reaction Turbines.

i) Propeller Turbine.
ii) Francis Turbine.
iii) Kinetic Turbine.

## Propeller turbine.

- A propeller turbine generally has a runner with three to six blades in which the water contacts all of the blades constantly. Picture a boat propeller running in a pipe.
- The pitch of the blades may be fixed or adjustable.

## Types of Propeller turbines.

i) Bulb Turbine
ii) Straflo Turbine
iii) Tube Turbine.
iv) Kaplan Turbine.

i) Bulb Turbines.

The turbine and Generation are a Sealed unit placed directly in the water Stream.

ii) Straflo Turbines.

The generator is attached directly to the perimeters of the turbine.

iii) Tube Turbines.

The penstock bends just before or after the runner.

iv) Kaplan Turbines.

Both the blades and the wicket gates are adjustable, allowing for a wider range of operation.

ii) Francis Turbines:-

A franeits turbine has a runner with fixed buckets (vanes), usually nine or more water is introduced above the runner and all around it and then falls through, causing it to spin. Besides the runner, the other major components are the scroll case, wicket gates, and draft tube.

iii) Kinetic Turbines.

Kinetic Turbines, also called free-flow turbines, generate electricity from the kinetic energy present in flowing water.

The ~~sy~~ systems may operate in rivers, man-made channels, tidal waters, or ocean currents. Kinetic system utilize the water stream's natural pathway. Kinetic system do not require large civil works; however, they can use existing structure such as bridges, and channels.

Q2(b)

Given Data.

Head = $h = 19m$

Discharge = $q = 2.2\ m^3/s$

overall Efficiency = $\eta = 88\%$ or $8.5$?

using the formula to calculate specific speed.

$$ns = \frac{88.49}{(h)^{0.243}}$$

$$ns = \frac{88.49}{(190)^{0.243}} = 23.88 \text{ rpm.}$$

using $P = \eta \rho q g h$

to obtain power output.

$$P = 0.88 \times 1000 \times 2.2 \times 9.81 \times 190$$

$$n = ns = 23.88 \times \frac{(190)^{3/4}}{\sqrt{3488.5}}$$

$= 288.32$ rpm.

The number of poles required are computed by

$$N_s = \frac{120f}{P}$$

The number of poles required are computed by

$$N_s = \frac{120f}{P}$$

$$P = \frac{120 \times 50}{285.32}$$

$$P = 21.02 \text{ poles.}$$

we will select 24 poles which will rotate at 250 rpm of 50 Hz.

so The Turbine will Diameter which which can be calculated by.

$$D = 38.567 \frac{\sqrt{4}}{n} = 38.567 \frac{\sqrt{190}}{250} = 2.12 m.$$

For Calculating Jet diameter.

$$q = \frac{\pi d_j^2 (V_j)}{4}$$

Jet velocity $= V_j = \sqrt{2gh}$

$= 2 \times 9.8 \times 190$

$= 61.08$ m/sec

There fore Jet diameter will be

$$d_j = \sqrt{\frac{4q}{\pi V_j}} = \frac{4 \times 2.2}{3.14 \times 61.07}$$

$= 0.214$ m

$d_j = 21.4$ cm

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## Nuclear Fuel cycle.

* The nuclear fuel cycle is the Series of industrial processes which involve the Production of electricity from uranium in nuclear Power reactors.

* Uranium is a relatively Common element that is found throughout the world. It is mined in a number of Countries and must be processed before it can be used as fuel for a nuclear reactor.

* Fuel removed from a reactor after it has reached the end of its useful life can be reprocessed so that most is recycled for new fuel.

# Mining and Milling.

Uranium is usually mined by either surface (open cut) or underground mining techniques, depending on the depth at which the ore body is found.

* From these, the mined uranium ore is sent to a mill which is usually located close to the mine.

* At the mill the ore is crushed and ground to a fine slurry which is leached in sulfuric acid to allow the separation of uranium from the waste rock.

* It is then recovered from solution as uranium oxide ($U_3O_8$) concentrate.

* Sometimes this is known as "Yellowcake".

Conversion:

* Because uranium needs to be in the form of a gas before it can be enriched, the $U_3O_8$ is converted into the gas uranium hexafluoride ($UF_6$) at a conversion plant.

Enriching.

* Need to enrich uranium to at least 3% for a Power Plant.

* Two Methods of Enriching

* Gaseous Diffusion Method.
* $UF_6$ (hexafluoride) gas heated
* U-238 is heavier than U-235
* Hexafluoride Gas can be separated into two streams.

* Low velocity U-238
* High Velocity U-235

* Centrifuge Method
* Gas spun in Centrifuge
* Lighter U-235 will separate from heavier U-238.

## Fuel Conversion.

* Enriched Uranium transported to a fuel fabrication plant where it is converted to uranium dioxide ($UO_2$) powder and pressed into small pellets.

* These pellets are inserted into thin tubes, usually of a Zirconium alloy, or stainless steel, to from fuel rods.

* The rods are then sealed and assembled clusters to form fuel assemblies for use in the core of the nuclear reactor.

# Fuel Packaging in the Core

* Rods contain uranium enriched.

* Need roughly 100 tons per year for a 1000 MW plant.

## The Reactor Core.

* The reactor core consists of fuel rods and control rods
* Fuel rods contain enriched uranium.
* Control rods are inserted between the fuel rods to absorb neutrons and slow the chain reaction

* Control rods are made of Cadmium, which absorb neutrons effectively.

# Moderators.

* ~~Atel~~ Neutrons produced during fission in the core are moving too fast to cause chain reaction.
* Note:
  This is not an issue with a bomb, where fissile uranium is so tightly packed that fast moving neutrons can still do the job.

* A moderator is required to slow down the neutrons.

* In Nuclear power plants water or graphite acts as the moderator.

# Light vs. Heavy water:

* 99.99% of water molecules contain normal hydrogen (i.e. with a single proton in the nucleus)
* water can be specially ~~what~~ prepared so that the molecules contain deuterium (i.e hydrogen with a proton and a neutron in the nucleus)
* Normal water is called light water while water containing deuterium is called heavy water.
* Heavy water is a much better moderator but is very expensive to make

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## Boiling water Reactor (BWR).

* Heat generated in the core is used to generated steam through a heat exchanger.

* The steam runs a turbine just like a normal power plant

## Pressurized water Reactor (PWR)

* water in the core heated top 315°C but is not turned into steam due to high pressure in the Primary loop.

* Heat exchanger used to transfer heat into Secondary loop where water is turned steam to power turbine.

* Steam used to power turbine never comes directly in

# PWR vs. BWR

## LIGHT WATER REACTOR FUEL DATA

| | BWR | PWR |
|---|---|---|
| Electrical output (MWe) | 1000 | 1000 |
| Initial load (tons of uranium oxide) | 135 | 80 |
| Fuel rods per assembly | 50 | 200 |
| Fuel assemblies per core | 750 | 180 |
| Number of control rods | 180 | 45 |

## Uranium Reprocessing:

* Spent fuel still contains approximately 96% of its original uranium, of which the fissionable U-235 content has been reduced to less than 1%.
* Spent fuel comprises waste products and the remaining 1% is plutonium produced while the fuel was in the reactor.
* Reprocessing extracts useable fissile U-238.

# Nuclear Waste Disposal.

* In the U.S, no hight-level nuclear waste is ever disposed of - it sits in specially designed pools resembling large swimming pool (water cools the fuel and acts as a radiation shield) or in specially designed storage containers.

* Spent nuclear fuel must be isolated for thousands of years

* After 10,000 years of radioactive ~~do~~ decay, according to EPA standards, the spent nucler fuel will no longer pose a threat to public health. ~~and~~