M.E. WATER RESOURCES AND HYDRAULIC ENGG.

FIRST YEAR SECOND SEMESTER - 2025

GROUND WATER DYNAMICS

Time: Three Hours Full Marks :100

Answer any *five* questions.

1.a) In a homogeneous isotropic confined aquifer of constant thickness of 20 m, effective porosity of 20 % and permeability of 15 m/day, two observation wells 1200 m apart indicate piezometric heads of 5.4 m and 3.0 m, respectively, above MSL. Assuming uniform flow, average grain diameter of sand 1 mm and ν of water (kinematic viscosity) = 0.01 cm^2 /sec, state

i) Whether Darcy's law is applicable? State the limitation of Darcy's law.

ii) What is the average flow velocity in pores?

b) Prove that the co-efficient of permeability of a soil is directly proportional to the square of the effective grain size of the soil particles and the same is inversely proportional to the kinematic viscosity.

12+8 =20

2. a) Show that the governing equation for 3-D groundwater flow equation in case of homogenous, isotropic and unsteady in case of polar coordinate and write all assumptions considered in this given equation.

$$\frac{\partial^2 \emptyset}{\partial r^2} + \frac{1}{r}\frac{\partial \emptyset}{\partial r} + \frac{1}{r^2}\frac{\partial^2 \emptyset}{\partial \theta^2} = \frac{S_s}{K}\frac{\partial \emptyset}{\partial t}$$

Where ϕ is the piezometric head, r is the radial distance, θ is the angle, Ss is the specific storage and K is the hydraulic conductivity.

b) The coefficient of storage of an artesian aquifer is 3 * 10^{-4}. If the thickness of the aquifer is 50 m and the porosity 30 %, estimate the fraction of the coefficient of storage attributable to expansibility of water and that attributable to compressibility of the aquifer skeleton K_w = 2.1 GN/m^2. Assume any data if required.

15+5=20

3. a) Prove that the governing 1-D equation for steady radial flow into a well for a confined isotropic and homogeneous aquifer is given below and write all assumptions considered in this equation:

$$\frac{\partial^2 \emptyset}{\partial r^2} + \frac{1}{r}\frac{\partial \emptyset}{\partial r} = 0$$

b) An aquifer of aerial extent of 100 km^2 is overlain by four strata as given below:

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Strata	Thickness (m)	K_x (m/day)	K_y (m/day)
1 (top)	1	1	0.25
2	2	2	0.3
3	3	1.5	0.2
4	4	0.025	0.005

If a 4-hour storm occurs producing a total rainfall 100 mm, estimate the recharge into the aquifer, assuming that the piezometric surface in the aquifer is at the bottom of layer 4 and that all layers are saturated.

13+7=20

4.a) Establish the relationship between the drawdown (s) and the well function [W(u)], discharge (Q) and transmissibility (T) in a confined aquifer in unsteady-state solutions which describes the transient drawdown in the piezometric head caused by a fully penetrating pumping well.

b) A well is located in a 25 m confined aquifer of permeability 30 m/day and storage coefficient 0.005. If the well is being pumped at the rate of 1750 lpm, calculate the drawdown at a distance of 50 m from the well after 20 hours of pumping.

15+5=20

5. a) In a test of a confined aquifer, the pumping rate was 500 m^3/day. Drawdown and time data were collected at an observation well 300 m away.

Time(min)	S(m)	Time(min)	S(m)
1.00	0.03	35.62	1.79
1.27	0.05	45.20	1.97
1.61	0.09	57.36	2.15
2.04	0.15	72.79	2.33
2.59	0.22	92.37	2.52
3.29	0.31	117.21	2.70
4.18	0.41	148.74	2.89
5.30	0.53	188.74	3.07
6.72	0.66	239.50	3.26
8.53	0.80	303.92	3.45
10.83	0.95	385.66	3.64
13.74	1.11	489.39	3.83
17.43	1.27	621.02	4.02
22.12	1.44	788.05	4.21
28.07	1.61	1000.00	4.39

b) Prove that drawdown (s) using Cooper-Jacob Method is given by:

$$s = \frac{2.3Q}{4\pi T} \log\left(\frac{2.25Tt}{r^2 S}\right)$$

Where Q is the pumping rate, T is transmissivity, S is storativity, t is time, and r is the radial distance.

14+6=20

6. a) "It is good practice to measure residual drawdowns"- Justify the statement

b) A 30 cm well was pumped at a uniform rate of 2500 m3/day. The pump was shut down after 240 min. The pumping was stopped and the residual drawdowns during recovery in different time are given in Table below. Determine the transmissivity T .

Recovery time t" (min)	Residual drawdown s" (m)	Recovery time t" (min)	Residual drawdown
1	0.89	30	0.38
2	0.81	40	0.34
3	0.76	60	0.28
5	0.68	80	0.24
7	0.64	100	0.21
10	0.56	140	0.17
15	0.49	180	0.14
20	0.55		

5+15=20

7.a) Briefly describe the approach and objective of groundwater modelling

b) Briefly describe the common mistakes in groundwater modelling

c) An R.C network analog has to be constructed to simulate a confined aquifer of 40 km × 60 km with an average thickness of 30 m, permeability of 25 m/day, and storage coefficient 4×10^{-4}. The maximum head is 40 m. The model can be represented by 40 × 60 nodes. Resistor of 3000 Ω and capacitors of 0.01 μF are available; model voltage =8 V. Work out the scale factors. If a calibrating resistor of 2500 Ω is used for simulating pumping rate, determine the current pulse and excitation voltage to simulate a pumping rate 1000 m^3/day at a particular node.

6+4+10=20

8. (a) Briefly describe the term "response of an unconfined aquifer to pumping."

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(b) A test was conducted with an unconfined aquifer near Burdwan, Damodar River. The well was pumped at constant rate of 20,000 m^3/day. The drawdown measured in an observation well 10 m away are listed in the table below. Aquifer thickness is 14 m. Assuming fully penetrating well calculate the hydraulic parameters for the aquifer using Neuman's straight-line method.

Time Since Pumping (Minutes)	**Drawdown (m)**	**Time Since Pumping (Minutes)**	**Drawdown (m)**	**Time Since Pumping (Minutes)**	**Drawdown (m)**	**Time Since Pumping (Minutes)**	**Drawdown (m)**
1	0.07	40	0.178	85	0.207	720	0.259
2	0.08	41	0.18	90	0.21	840	0.26
3	0.09	42	0.18	95	0.21	960	0.267
4	0.095	44	0.18	100	0.21	1080	0.269
5	0.1	46	0.185	105	0.212	1200	0.27
6	0.11	48	0.188	110	0.212	1320	0.27
7	0.13	50	0.19	115	0.218	1440	0.278
8	0.13	52	0.19	120	0.218	1560	0.28
9	0.13	54	0.193	130	0.22	1680	0.28
10	0.13	56	0.193	140	0.22	1800	0.285
12	0.135	58	0.193	150	0.225	1920	0.287
13	0.14	60	0.193	210	0.238	2040	0.29
14	0.141	62	0.199	240	0.24	2160	0.293
15	0.145	64	0.2	270	0.24	2280	0.293
16	0.145	66	0.2	300	0.241	2400	0.295
17	0.147	68	0.204	330	0.243	2520	0.299
18	0.147	70	0.205	360	0.243	2640	0.299
19	0.149	75	0.207	420	0.25	2760	0.3
20	0.149	80	0.207	600	0.259	2880	0.3

4+16=20