M.E. WATER RESOURCES AND HYDRAULIC ENGG.(6- Semester Course)
2nd YEAR SECOND SEMESTER - 2025
Groundwater Dynamics
(Paper - II)

Time: Three hours Full Marks: 100

Answer any five Question

1.(a) In a phreatic aquifer extending over 1 km^2 the water table was initially at 25 m bgl. Sometime after irrigation with depth of 20 cm of water, the water table rose to a depth of 24 m bgl. Later 3 x 10^5 m^3 of water was pumped out and the water table dropped to 26.2 m bgl. Determine (i) specific yield of the aquifer (ii) deficit in soil moisture (below field capacity) before irrigation.

(b) Write down the limitations of Darcy's Law.

(c) How the intrinsic permeability is related to structure coefficient, porosity function and effective grain size? Derive it with dimensional analysis.

8+2+10=20

2. (a) Deduce the 2D governing in polar coordinates equation for unsteady, incompressible, anisotropic, homogenous unconfined aquifer with recharge.

(b) An artesian aquifer 25 m thick has a porosity of 20% and the bulk modulus of compression 2.1 GN/m^2. Estimate the storage coefficient of the aquifer. Assume modulus of elasticity of the soil skeleton = 3x10^8 N/m^2.

16+4=20

3. (a) Deduce the governing 1-D equation in polar coordinates for steady radial flow into a well for a confined, isotropic and homogenous aquifer.

(b) During a falling head permeability test on a soil sample of 10 cm diameter and 20 cm length, the head in the stand pipe of 2 cm diameter dropped from 50 cm to 25 cm in 2 min. Determine the permeability of the sample in SI unit.

15+5=20

[Turn over

4. (a) Show that equation which describes the transient drawdown in the piezometric head caused by a fully penetrating pumping well in a confined aquifer in unsteady-state solutions

$$s'(u) = \frac{Q}{4\pi T} W(u)$$

Where $\int_u^\infty \frac{e^{-x}}{x} dx$ = W(u)= Well function and $S'(u) = drawdown$, T= Transmissivity, Q =discharge of well

(b) A well is located in a 25 m confined aquifer of permeability 30 m/d and storage coefficient 0.005. If the well is being pumped at the rate of 1750 lpm, calculate the drawdown (in m) at a distance of 10 m from the well after 20 h of pumping.

14+6=20

5. (a) Why Copper-Jacob straight line method is advantageous over the Thies method? State its limitations.

(b) The transmissivity and storativity of a confined aquifer are 1000 m^2/day and 0.0001, respectively. An observation well located 500 m away from the pumping well. For a pumping period of 220 min, calculate

i) the drawdown at the observation well if the discharge rate is 1000 m^3/day:

ii) the pumping rate required to provide a drawdown of 2 m at that well after 220 minutes.

(c) Prove that drawdown (s) can be expressed by "Copper-Jacob Method" is

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

where Q is the discharge of pumping well, T and S are the Transmissivity and Storativity with time 't' and r is the radial distance between main well to observation well.

6+8+6=20

6. (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 (table given below).

Determine the transmissivity and storativity of the aquifer using the Copper-Jacob Straight Line Method.

Table: Drawdown measured 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

Table 5.1 Values of $W(u)$ for values of u (abridged, after Wenzel, 1942)

u	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
$\times 1$	0.219	0.049	0.013	0.0038	0.0011	0.00036	0.00012	0.000038	0.000012
$\times 10^{-1}$	1.82	1.22	0.91	0.70	0.56	0.45	0.37	0.31	0.26
$\times 10^{-2}$	4.04	3.35	2.96	2.68	2.47	2.30	2.15	2.03	1.92
$\times 10^{-3}$	6.33	5.64	5.22	4.95	4.73	4.54	4.39	4.26	4.14
$\times 10^{-4}$	8.63	7.94	7.53	7.25	7.02	6.84	6.69	6.55	6.44
$\times 10^{-5}$	10.94	10.24	9.84	9.55	9.33	9.14	8.99	8.86	8.74
$\times 10^{-6}$	13.24	12.55	12.14	11.85	11.63	11.45	11.29	11.16	11.04
$\times 10^{-7}$	15.54	14.85	14.44	14.15	13.93	13.75	13.60	13.46	13.34
$\times 10^{-8}$	17.84	17.15	16.74	16.46	16.23	16.05	15.90	15.76	15.65
$\times 10^{-9}$	20.15	19.45	19.05	18.76	18.54	18.35	18.20	18.07	17.95
$\times 10^{-10}$	22.45	21.76	21.35	21.06	20.84	20.66	20.50	20.37	20.25
$\times 10^{-11}$	24.75	24.06	23.65	23.36	23.14	22.96	22.81	22.67	22.55
$\times 10^{-12}$	27.05	26.36	25.96	25.67	25.44	25.26	25.11	24.97	24.86
$\times 10^{-13}$	29.36	28.66	28.26	27.97	27.75	27.56	27.41	27.28	27.16
$\times 10^{-14}$	31.66	30.97	30.56	30.27	30.05	29.87	29.71	29.58	29.46
$\times 10^{-15}$	33.96	33.27	32.86	32.58	32.35	32.17	32.02	31.88	31.76

Example: For $u = 3.0 \times 10^{-4}$, $W(u) = 7.53$

(b) "It is good practice to measure residual drawdowns"- Justify the statement

2+18=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 6 km X 4 km extent having a uniform saturated thickness of 50 m, permeability of 3 m/day, and storage coefficient 10-3. The aquifer may be divided into gid of 1km*1 km. 1 sec. in the analog should represent 1000 days for the aquifer. Restore of 1 megaohm are available and 1 m head of water should represent 1 volt in analog. Work out the scale factor for resistance and discharge. What capacitance should be required for each block.

6+4+10=20

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

(b) A test was conducted with an unconfined aquifer near Burdwan, Damodar River. The well was pumped at constant rate of 2040 m^3/day. The drawdown measured in an observation well 10 m away are listed in below table. 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

3+17=20