M.E. (Water Resources and Hydraulic Engineering) EXAMINATION, 2019

(First Year-2nd Semester)

Groundwater Dynamics

Paper-VIII

Time: Three hours Full Marks: 100

Answers any five

1. (a) Derive the governing equation for the two dimensional flow in an unconfined aquifer of a homogenous fluid in anisotropic homogenous porous media based on Dupuit approximation.

(b) A homogeneous anisotropic confined aquifer is 25 m thick and has principal hydraulic conductivities of K_{xx} = 34 m/d and K_{yy} = 15 m/d. Determine the principal transmissivities and state the differential equation describing the piezometric head distribution in the absence of recharge. Would the governing equation be any different if the aquifer were 50-m thick, K_{xx} = 17 m/d, and K_{yy} = 7.5 m/d?

(15+5)=20

2. (a) Deduce the governing equation for radial flow in a confined steady, homogenous and isotropic aquifer.

(b) Two observation wells were found at horizontal distance of 16 m and 34 m from the pumping well. The drawdowns were observed as 2.45 m and 1.20 m during pumping. The initial position of the water table was 2.2 m and aquifer thickness was 14.5 m. Calculate the coefficient of permeability if the pumping rate is 1500 L/min.

(14+6)=20

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

(b) A well penetrating a confined aquifer is pumped at a uniform rate of 2500 m^3/day. Drawdowns during the pumping period are measured in an observation well 60 m away, observations of 't' and 's' are listed below in a tabulated form.

Time, t(min)	s(m)	Time, t (min)	s(m)
0	0	24	0.72
1	0.020	30	0.76
1.5	0.27	40	0.81
2.0	0.30	50	0.85
2.5	0.34	60	0.90
3.0	0.37	80	0.93
4.0	0.41	100	0.96
5.0	0.45	120	1.00
6	0.48	150	0.104
8	0.53	180	1.07
10	0.57	210	1.10
12	0.60	240	1.12
14	0.63		
18	0.67		

The well function W(u) and u are also given in a tabular form

u	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
W(u)	0.219	1.82	4.04	6.33	8.63	10.94

Calculate transmissivity and storativity of the confined aquifer using Theis Method.

(4+16)=20

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

(b) Prove that drawdown (s) can be expressed by "Copper-Jacob Method" with the series expression for W(u) by equation

$$W(u) = -0.5772157 - \ln(u)$$

is given by

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

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.

15+5=20

5. (a) A 30 cm well was pumped at a uniform rate of 2500 m^3/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 s' (m)
1.0	0.89	30.0	0.38
2.0	0.81	40.0	0.34

3.0	0.76	60.0	0.28
5.0	0.68	80.0	0.24
7.0	0.64	100.0	0.21
10.0	0.56	140.0	0.17
15.0	0.49	180.0	0.14
20.0	0.55		

(b) 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 (12+8)=20

6. (a) What are the factors depends on coefficient of permeability in case of porous material? Deduce an expression the coefficient of permeability for fined grained soils.

(b) Derive the functional relationship between the hydraulic conductivity and the fluid and solid-matrix properties using dimensional analysis.

(c) Constant head permeability test was carried out on a cylindrical sample of sand 10.2 cm in diameter and 14 cm in height. If 162 cm^3 of water was collected in 1.70 minutes under a 25 cm head, calculate the coefficient of permeability and velocity of flow.

(6+7+7)=20

7. (a) A confined aquifer of thickness 30 m is pumped at a rate of 6480 m3/d from a well of radius 0.3 m. The superposition of the W(u) versus ln (u) curve onto the ln (s) versus in (r2/t) curve is found with the help of time versus drawdwon data in a monitoring well located 100 m from the pumping well, and the axis displacement indicates that α = 15.1 and β = (-) 0.557, calculate the value of transmisivity (T) in m^2/d.

(i) 900 (ii) 1000 (iii) 1100 (iv) 1200

b) By considering the above problem 'a', what is the storage co-efficient of the aquifer?

(i) 0.0001 (ii) 0.0010 (iii) 0.00001 (iv) 0.010

c) By considering the above problem 'a', what is the hydraulic conductivity (in m/d) of the aquifer?

(i) 10 (ii) 20 (iii) 30 (iv) 40

d) The hydraulic conductivity distribution in a 30-m thick stratified aquifer is given in the following table

Depth (m)	K_{xx}	K_{yy}	Depth (m)	K_{xx}	K_{yy}	Depth (m)	K_{xx}	K_{yy}
0-5	25	30	5-10	30	33	10-15	40	37
15-20	32	28	20-25	22	19	25-30	13	11

Estimate the effective hydraulic conductivity (in m/d) when the table is 4 m below the ground surface

(i) 27.3 and 25.8 (ii) 30.3 and 28.8 (iii) 33.3 and 31.8 (iv) 36.3 and 34.8

e) By considering the above problem 'd', would the effective hydraulic conductivity (in m/d) be the same at a location where the water table is 5 m below the ground surface?

(i) 27.4 and 25.6 (ii) 30.4 and 28.6 (iii) 33.4 and 31.6 (iv) 36.4 and 34.8

f) What is the well function 'W(u)', if 'u' is a dimensionless term to be estimated as 1.01×10^{-10}? Assume neglecting second and higher order terms.

(i) 22.44 (ii) 32.44 (iii) 42.44 (iv) 52.44

g) For the well, determine the 'u' value at the well where radius of well and the radial distance are 304.8 mm and 1000 mm respectively after 1 year of pumping at a rate of 500 m^3/d with a transmissivity of the aquifer of 879 m^2/d. The storage co-efficient of the aquifer is 0.00035.

(i) 1.53×10^{-11} (ii) 2.53×10^{-11} (iii) 3.53×10^{-11} (iv) 4.53×10^{-11}

h) If W(u) value is found to be 32.84, determine the drawdown at the well in case of unsteady-state confined aquifer. The well is being pumped at a rate of 500 m^3/d with a transmissivity of the aquifer of 879 m^2/d.

i) 1.5 m ii) 2.5 m iii) 3.5 m iv) 0.5 m

i) During a falling head permeability test, the initial head at t_1=30 min is 80 cm. At t_2=60 min, the head is 75 cm. The diameter of the standpipe and the specimen are 1.5 cm and 20 cm, respectively. The length of the specimen is 30 cm. Determine the hydraulic conductivity of the specimen.

(j) 6.04×10^{-8} m/s (ii) 7.04×10^{-5} m/s (iii) 6.04×10^{-5} m/s (iv) 7.04×10^{-8} m/s

J) What is the entrance velocity, the if the well discharge, clogging coefficient, screen diameter, screen length and the percentage of open area in the screen are 50 m^3/h, 0.5, 100 mm, 20 m and 60% respectively?

(k) 0.0074 m/s (ii 0.074 m/s (iii) 0.0094 m/s (iv) 0.094 m/s

(2x10)=20