

**M.E. (Water Resources and Hydraulic Engineering) EXAMINATION  
(Evening), 2018  
(Second Year-2<sup>nd</sup> Semester)  
Groundwater Dynamics**

Time: Three hours

Full Marks: 100

**Answers any five**

1. (a) Groundwater flows through a buried-valley aquifer with a cross-sectional area of  $105 \text{ m}^2$  and length of  $6116 \text{ m}$ . Hydraulic heads at the ground-water entry and exit points in the aquifer are  $306 \text{ m}$  and  $294 \text{ m}$  respectively. At the downstream end of the aquifer, groundwater discharges into a stream at a rate of  $2857 \text{ m}^3/\text{day}$ . What is the hydraulic gradient?

- (i) 0.002                      (ii) 0.004                      (iii) 0.006                      (iv) 0.008

b) An intrinsic permeability of 100 darcys, a temperature of  $20^\circ\text{C}$  (dynamic viscosity= $0.001 \text{ Ns/m}^2$ , specific weight =  $9790 \text{ N/m}^3$ ), what is the hydraulic conductivity?

- (i)  $63.7 \text{ m/d}$                       (ii)  $83.7 \text{ m/d}$                       (iii)  $93.7 \text{ m/d}$                       (iv)  $33.7 \text{ m/d}$

c) The specific discharge of the aquifer is found to be  $0.32 \text{ m/d}$  and it is to be travelled from one point to another point covering a distance of  $1 \text{ km}$  with effective porosity of  $0.2$ , what is pore ground water velocity?

- (i)  $2.0 \text{ m/day}$                       (ii)  $1.6 \text{ m/day}$                       (iii)  $0.16 \text{ m/day}$                       (iv)  $0.2 \text{ m/day}$

d) By considering the above problem 'c', what is the travel time from one point to another point to reach water?

- (i) 2.0 years                      (ii) 2.5 years                      (iii) 3.0 years                      (iv) 3.5 years

e) A  $609.6 \text{ mm}$  diameter well is installed in a confined aquifer using a  $152.4 \text{ mm}$  gravel pack. The aquifer has a transmissivity of  $879 \text{ m}^2/\text{d}$ , and the well is pumped at a rate of  $500 \text{ m}^3/\text{d}$ . If the radius of influence of the well is  $150 \text{ m}$ , determine the steady-state drawdown at the well.

- (i)  $0.77 \text{ m}$                       (ii)  $0.87 \text{ m}$                       (iii)  $0.97 \text{ m}$                       (iv)  $1.07 \text{ m}$

f) What is the well function ' $W(u)$ ', if ' $u$ ' is a dimensionless term to be estimated as  $1.01 \times 10^{-10}$ ? 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  $304.8 \text{ mm}$  and  $1000 \text{ mm}$  respectively after 1 year of pumping at a rate of  $500 \text{ m}^3/\text{d}$  with a transmissivity of the aquifer of  $879 \text{ m}^2/\text{d}$ . The storage co-efficient of the aquifer is  $0.00035$ .

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

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  $500 \text{ m}^3/\text{d}$  with a transmissivity of the aquifer of  $879 \text{ m}^2/\text{d}$ .

- 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  $t_1=30 \text{ min}$  is 80 cm. At  $t_2=60 \text{ min}$ , 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)  $6.04 \times 10^{-8} \text{ m/s}$                       (ii)  $7.04 \times 10^{-5} \text{ m/s}$                       (iii)  $6.04 \times 10^{-5} \text{ m/s}$                       (iv)  $7.04 \times 10^{-8} \text{ m/s}$

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  $50 \text{ m}^3/\text{h}$ , 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

2. (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 confined aquifer composed of a dense sandy-gravel matrix is 20 m thick and has a porosity of 0.3. If the compressibility co-efficient of water and solid matrix of the aquifer material is estimated to be  $8 \times 10^{-9} \text{ m}^2/\text{kN}$  and  $1 \times 10^{-8}$  respectively, estimate the storage coefficient of the aquifer. Compare your result with the empirical equation. Assume  $\gamma = 9790 \text{ Ns/m}^2$ .  
(16+4)=20

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

(b) A two-layered soil system consists of horizontal layers that are each 6 m. Beneath the fine silt layer ( $k_2$  equals  $10^{-8} \text{ m/s}$ ) is a stratum of water-bearing gravel with a water pressure of  $155 \text{ kN/m}^2$ . The surface of the sand ( $k_1$  equals  $10^{-7} \text{ m/s}$ ) is flooded with water to a depth of 1 m. Determine the quantity of flow per unit area.

(15+5)=20

4. 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  $2500 \text{ m}^3/\text{day}$ . 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	$10^{-1}$	$10^{-2}$	$10^{-3}$
$W(u)$	0.219	1.82	4.04	6.33

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

(4+16)=20

5. (a) In a test of a confined aquifer, the pumping rate was  $500 \text{ m}^3/\text{day}$ . 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

(b) 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.

15+5=20

6. (a) A 30 cm well was pumped at a uniform rate of 2500 m<sup>3</sup>/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	0.89	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		

(b) Show that equation which describes the transient drawdown in the piezometric head caused by a fully penetrating pumping well in a confined aquifer

$$s(u) = \frac{Q_w}{4\pi T} \int_u^\infty \frac{e^{-u}}{u} du$$

(12+8)=20

7. (a) What are the factors depends on coefficient of permeability in case of porous material? Name two methods to determine the coefficient of permeability in the laboratory by a permeameter. 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) The hydraulic conductivity in a 30-m thick stratified aquifer is given in the following table

Depth (m)	K <sub>xx</sub> (m/d)	K <sub>yy</sub> (m/d)
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 horizontal and vertical hydraulic conductivity when the water table is 3.5 m below the ground surface.

(8+8+4)=20