DARBHANGA COLLEGE OF ENGINEERING

COURSE FILE

OF

GROUND WATER ENGINEERING (011886)

Faculty Name:

AHSAN RABBANI

Assistant Professor, DEPARTMENT OF CIVIL ENGINEERING

विज्ञान एवं प्रावैधिकी विभाग
Department of Science and Technology
Government of Bihar

CONTENTS

DEPARTMENT OF CIVIL ENGINEERING

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

VISION

Department of Civil Engineering is striving to become a premier academic centre for quality Education, Entrepreneurship and Research in different areas of civil engineering with a strong social commitment.

MISSION

1. To produce highly competent and technologically capable professionals by collaboration with relevant industries.
2. To motivate graduates towards innovation and research in the field of civil engineering.
3. To provide quality education in undergraduate levels with strong emphasis on professional's ethics and social commitment.

CIVIL ENGINEERING PROGRAM EDUCATIONAL OBJECTIVES

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1	To prepare our graduates to have successful careers in design and analysis of various Civil Engineering structures and also motivate them to pursue higher studies and research in the relevant fields.
PEO2	To prepare our graduates as a good cognizance of Societal, Environmental and Ethical issues and have effective communication skills.
PEO3	To develop awareness of contemporary professionals issues and encourage them to support the Engineering profession through contribution in professional's societies and/or Educational Institutions.

PROGRAM SPECIFIC OUTCOMES (PSOs)

The PSOs of Civil engineering programme supported by the curriculum are given below.

PSO1	To function as design consultants in the relevant industry for the design of civil engineering structures using modern software tool.
PSO2	To develop knowledge in some specific technical areas of civil engineering; Structural, Geotechnical, Transportation, Earthquake and Environmental engineering.

PROGRAMME OUTCOMES (PO)

PO1	**Engineering knowledge**: An ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to get the solution of the engineering problems.
PO2	**Problem analysis:** Ability to Identify, formulates, review research literature, and analyze complex engineering problems.
PO3	**Design/development of solutions:** Ability to design solutions for complex engineering problems by considering social, economical and environmental aspects.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge to design, conduct analyse experiments to get valid conclusion.
PO5	**Modern tool usage:** ability to create, select, and apply appropriate techniques, and to model complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Ability to apply knowledge by considering social health, safety, legal and cultural issues.
PO7	**Environment and sustainability:** Understanding of the impact of the adopted engineering solutions in social and environmental contexts.
PO8	**Ethics**: Understanding of the ethical issues of the civil engineering and applying ethical principles in engineering practices.
PO9	**Individual and teamwork:** Ability to work effectively as an individual or in team, as a member or as a leader.
PO10	**Communication:** An ability to communicate clearly and effectively through different modes of communication.
PO11	**Project management and finance:** Ability to handle project and to manage finance related issue
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning.

Course Description:

This course is designed to review the fundamentals and practices of Ground Water engineering within the Civil Engineering curriculum. This course is an advanced, graduate level, course dealing with the important concepts associated with ground water flows in natural and altered environments. The main goals of the course are (1) cover the fundamental calculations and problems with Ground Water situations; and (2) apply state of the science approaches and models to actual Ground Water problems.

Course Objectives:

Objective of this course is to introduce the students to the fundamentals of ground water flow, distribution of ground water, concept of aquifers, flow in confined and unconfined aquifers, interference among wells, well hydraulics, ground water development, ground water exploration by different techniques.

Course Outcome (5):

At the end of this course, the students will

CO1: Understand the process of ground water development in India and concept of subsurface water

CO2: Evaluate various equations for the flow of fluids through different media

CO3: Understand the flow towards well aquifers, specific yield, storage co-efficient, and discharge of a well as a function of drawdown

CO4: Understand well efficiency, radius of influence, lowering of ground water table and well losses

CO5: Analyze the geophysical investigation and ground water quality

CO-PO MAPPING

Mapping of COs and POs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	1	1	3	1	1	1	-	2
CO2	3	3	1	2	-	2	2	1	-	-	-	1
CO3	3	2	1	1	1	2	3	1	2	1	1	2
CO4	3	2	-	2	1	1	2	1	2	1	1	2
CO5	3	3	1	3	-	2	3	1	3	1	2	3

Mapping of COs and PSOs:

CO/PSO	PSO1	PSO2
CO1	2	3
CO2	3	2
CO3	3	1
CO4	2	1
CO5	3	2

Correlation Level: 1- Slight (Low) 2- moderate (Medium) 3 – Substantial (High)

COURSE SYLLABUS

Subject: Ground Water Engineering Code: 011855 Credit: 3

1.Introduction : Ground water development in India. Characteristics of fluid and the Medium. Soil moisture, Classification of subsurface water, Darey's law, Range of validity of Darey's law, Co-efficient of permeability.

2.General Hydro-dynamical Equations for the flow of Fluids through Porous media. The Equation of continuity, Equation of motion, Dupuit's equations for unconfined seepage flow, Plane free surface flow with horizontal impervious base without infiltration. Plane free surface flow with horizontal impervious boundary with infiltration and evaporation. Confined and semi-confined flow.

3.Mechanics of Flow towards Well aquifers, Classification. Specific yield, Storage co-efficient, Land susidence due to ground water withdrawals, unconfined wells. Discharge of an ordinary perfect well as a function drawdown.

4.Unconfined flow towards well with uniform infiltration from the ground surface. Confined radial flow towards the well. Discharge as a function of drawdown, well efficiency, Radius of influence, Determination of permeability by one or two well methods.

5.Lowering of ground water table, Unsteady confined flow, Well losses.

6.Geophysical Investigations Surface geophysical techniques, Electrical resistivity, Seismic refraction and reflection, other methods.

7. **Ground Water Quality :**Water sampling, Potable water standards of WHO, Ground Water Basin Management and Conjuctive Use of Surface and Ground Water A case study, Investigation design, construction and maintenance of tube, wells, filter materials and education wells.

Text Books :

1.Ground water Hydrology by M. H. Raghunath, New Age Publication, New Delhi.
2.Irrigation Engineering and Hydraulic Structures by Sahasrabuddhe. S. R., Katson, Ludhiana, 1975.

Reference Book :

1. 'Ground Water Hydrology' by Todd, David Keith (2007), Wiley India Edition, New Delhi –110002.

Time Table: 8th Semester

Darbhanga College of Engineering, Darbhanga — wef: 07/01/2019

8th Semester

DAY	Dept.	09:10-10:00 (1)	10:00-10:50 (2)	10:50-11:40 (3)	11:40-12:30 (4)	12:30-1:00 (5)	01:00-01:50(6)	01:50-02:40 (7)	02:40-03:30 (8)	03:30-04:20 (9)
MONDAY	EE (S9)	DEC	MCT	PSD	PMIR	LUNCH		PSD/Project		
	CSE (S10)	PMIR [NA	DM [SK]	ICS	IS [PP]			PROJECT SEMINAR		
	ME (S11)		IP (VK)	MSD (AM)	MIS (CSD)			MSD LAB		
	CE (S12)		IWT	IE	GWE			PROJECT (PK)	PROJECT (JK)	
TUESDAY	EE (S9)	MCT	DEC	PMIR	PSD			Project/PSD		
	CSE (S10)	PMIR [NA	DM [SK]	ICS	IS [PP]			PROJECT SEMINAR		
	ME (S11)	SD (NP)	IP (VK)	MSD (AM)				PROJECT (MK/PK)		
	CE (S12)	CPM		IE	IWT		PSC	CS&E LAB (G-1)(AKASH)		
WEDNESDAY	EE (S9)	PMIR	MCT	DEC	PSD			Seminar/Project		
	CSE (S10)	PMIR [NA	DM [SK]	ICS	IS [PP]		IP&GIS	PROJECT SEMINAR		
	ME (S11)		SD (NP)	MIS (CSD)	IP (VK)			PROJECT		
	CE (S12)	IWT	PSC	PROJECT (	GWE			PROJECT (RS)		
THRUSDAY	EE (S9)	PSD	PMIR	MCT				Project/Seminar		Counseling
	CSE (S10)	PROJECT SEMINAR			DSP		IP&GIS	PROJECT SEMINAR		
	ME (S11)	IP (T)	MSD (AM)	SD (NP)				PROJECT (CPS/MR)		
	CE (S12)	GWE	CPM	PROJECT (AKASH)			PROJECT (AK)		PROJECT (LK)	
FRIDAY	EE (S9)	PSD	MCT	DEC				Project/Seminar		Counseling
	CSE (S10)	PROJECT SEMINAR			DSP		IP&GIS	PROJECT SEMINAR		
	ME (S11)	MIS (CSD)	SD (T)		IP (T)			PROJECT (PS/NP)		
	CE (S12)	PSC	IE	PROJECT (RR)				CS&E LAB (G-2)(RR)		
SATURDAY	EE (S9)	Project						Project		
	CSE (S10)	PROJECT SEMINAR			DSP			DM LAB		
	ME (S11)		SD (T)	MSD (AM)				PROJECT (VS/AM)		
	CE (S12)	PROJECT WORK					PROJECT (LK)		PROJECT (SSC)	

Sl.No.	Electrical and Electronics Enginering		Sl.No.	Computer Science and Engineering	
1	DEC	Mr. Deepak Singh	1	DM	Mr. Sunil Kumar Sahu
2	MCT	Mr. Sanjay Kumar	2	IP&GIS	Mr. Dhirendra Kumar
3	PMIR	Mr. Saurabh Kanth	3	IS	Mrs. Punam Prabha
4	PSD	Mr. Tabish Shanu	4	ICS	Dr. Ravi Ranjan
5	Seminar	Mr. Amit kumar	5	PMIR	NA
6	Project	Mr. Ravi Kumar/All faculty	6	Project	All Faculties
Sl.No.	**Mechanical Enginering**		**Sl.No.**	**Civil Engineering**	
1	IP	Mr. Vikash Kumar	1	IWT/IE	Mr. Loknath kumar
2	SD	Mr. Navdeep Pandey	2	GWT	Mr. Rohit Soni
3	MSD	Dr. Md. Asjad Mokhtar	3	CS&E	Mr. Akash/ Mr. R.R. Kumar
4	MIS	Computer Science Dept.	4	CPM	Mr. Jitendra Kumar
5	Project	Dr. C. P. Singh/Mr. Vishnu Singh	5	PSC	Mr. Ravi Ranjan Kumar
6	Project	All Faculties	6	Project	All Faculties

(Mr. Ravi kumar)
Co-Cordinator Time Table

(Dr. A. K. Choudhary)
Coordinator Time Table

(Dr. A. K. Rai)
PRINCIPAL

List of Student: B Tech Civil Engineering (8th Semester) 2015-2019

Sl. No.	Registration No.	Name of the Student
1	15101111001	SHUBHAM RANA
2	15101111002	SUMIT RANJAN
3	15101111003	RAJEEV RANJAN
4	15101111004	AKASH KUMAR
5	15101111005	MANISH KUMAR
6	15101111006	NEEL KUMAR
7	15101111007	AMIT KUMAR
8	15101111008	NIRAJ KUMAR
9	15101111009	ABHISHEK ANAND
10	15101111010	SUJEET KUMAR
11	15101111011	NIRAJ KUMAR
12	15101111012	NITIN KUMAR
13	15101111013	MD SHAHNAWAZ ALAM
14	15101111014	SUNNY PRABHAKAR
15	15101111015	ANIL KUMAR
16	15101111016	DAUD AHMAD
17	15101111017	ANIKET KUMAR
18	15101111018	SHUBHAM KUMAR
19	15101111019	SAURABH KUMAR MISHRA
20	15101111020	GAURAV KUMAR
21	15101111021	ABHAY KUMAR
22	15101111022	SONIKA KUMARI
23	15101111023	FARHAN AHMAD
24	15101111024	SHIVAM VIKAS
25	15101111025	ADITYA KUSHWAHA
26	15101111026	SANTOSH KUMAR
27	15101111028	ABHAY RAJ
28	15101111029	VICKRANT KUMAR
29	15101111030	MD ALEEM ANSARI
30	15101111031	PRASHANT KUMAR
31	15101111032	GYAN SHANKAR KUMAR
32	15101111033	MUKESH KUMAR
33	15101111034	SUNIL KUMAR MANDAL
34	15101111035	MD KADIR ANSARI
35	15101111036	ADITYA KRISHNA
36	15101111037	PRANAV KUMAR

37	15101111038	RAJA KUMAR
38	15101111039	SUJIT KUMAR
39	15101111040	CHANDAN KUMAR
40	15101111041	AKASH RAJ
41	15101111042	MEGHA KUMARI
42	15101111043	NEHA KUMARI
43	15101111044	SHASHANK KUMAR
44	15101111045	MD ALTAMAS
45	15101111046	KUMAR NIRAV
46	15101111047	SHAMBHU KUMAR
47	15101111049	VARSHA BHARTI
48	15101111050	MANISH KUMAR JHA
49	15101111051	SHYAM KISHOR SINGH
50	15101111052	PRABHAT KUMAR
51	15101111053	ABHISHEK KUMAR
52	15101111054	KUNAL KUMAR
53	15101111055	SUJEET KUMAR
54	15101111056	RAKESH KUMAR
55	15101111057	NEERAJ KUMAR MANDAL
56	15101111058	ANAMIKA KUMARI
57	15101111059	MD ASADULLAH
58	15101111061	PAPPU KUMAR
59	15101111062	ARTI KUMARI
60	16101111052	AMRENDRA KUMAR
61	16101111901	AMIT KUMAR
62	16101111902	DEEPAK KUMAR
63	16101111903	POOJA KUMARI
64	16101111904	NEERAJ NIRALA
65	16101111905	NIKKY KUMARI
66	16101111906	AMIT KUMAR
67	16101111907	MD KHALID
68	16101111908	MD NEMATULLAH ANSARI

Institute / School Name :	DARBHANGA COLLEGE OF ENGINEERING		
Program Name	**B.E. CIVIL**		
Course Code	CE 011855		
Course Name	GROUND WATER ENGINEERING		
Lecture / Tutorial (per week):	3/0	**Course Credits**	3
Course Coordinator Name	Mr. Ahsan Rabbani		

LECTURE PLAN

Topics	Lecture Number	Date on which the Lecture was taken
1. INTRODUCTION		
Ground water development in India. Characteristics of fluid and the Medium. Soil moisture,	**1,2**	
Classification of subsurface water, Darey's law,	**3**	
Darey's law,	**4,5**	
Range of validity of Darey's law,	**6**	
Range of validity of Darey's law,	**7**	
Co-efficient of permeability.	**8**	
2.		
General Hydro-dynamical Equations for the flow of Fluids through Porous media.	**9,10**	
Equation of continuity, Equation of motion,	**11,12**	
Dupuit's equations for unconfined seepage flow,	**13,14**	
Plane free surface flow with horizontal impervious base without infiltration.	**15,16**	
Plane free surface flow with horizontal impervious boundary with infiltration and evaporation. Confined and semi-confined flow.	**17,18**	
3.		
Mechanics of Flow towards Well aquifers,	**19**	
Classification. Specific yield,	**20**	
Storage co-efficient, Land susidence due to ground water withdrawals,	**21,22**	
unconfined wells.	**23**	
Discharge of an ordinary perfect well as a function drawdown.	**24,25**	
4.		
Unconfined flow towards well with uniform infiltration from the ground surface.	**26,27**	
Confined radial flow towards the well.	**28,29**	
Discharge as a function of drawdown, well efficiency, Radius of influence,	**29,30**	
Determination of permeability by one or two well methods	**31,32**	
5.		
Lowering of ground water table, Unsteady confined flow,	**33**	
Well losses.,	**34,35**	
6.		
Geophysical Investigations Surfacegeophysical techniques, Electrical resistivity,	**36**	
Seismic refraction and reflection, other methods.	**37**	
7.		
Ground Water Quality :Water sampling, Potable water standards of WHO, Ground Water Basin Management and Conjuctive Use of Surface and Ground Water A case study,	**38,39**	
Investigation design, construction and maintenance of tube, wells, filter materials and education wells.	**40**	

Code : 011855

B.Tech 8th Semester Exam., 2016

GROUNDWATER ENGINEERING

Time : 3 hours | *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin*

(ii) *There are* ***NINE*** *questions in this paper.*

(iii) *Attempt* ***FIVE*** *questions in all.*

(iv) *Question No.* ***1*** *is compulsory.*

1. Choose the correct option of the following (any *seven*) : 2×7=14

(a) A geological formation which is essentially impermeable for flow of water even though it may contain water in its pores is called

(i) aquifer

(ii) aquifuse

(iii) aquitard

(iv) aquiclude

(b) A stream that provides water to the water table is termed as

(i) affluent

(ii) influent

(iii) ephemeral

(iv) effluent

(c) The volume of water that can be extracted by force of gravity from a unit volume of aquifer material is called

(i) specific retention

(ii) specific yield

(iii) specific storage

(iv) specific capacity

(d) Which of the pairs of terms used in groundwater hydrology are not synonymous?

(i) Permeability and hydraulic conductivity

(ii) Storage coefficient and storativity

(iii) Actual velocity of flow and discharge velocity

(iv) Water table aquifer and unconfined aquifer

(e) Darcy's law is valid in a porous media flow if the Reynolds number is less than unity. This Reynolds number is defined as

(i) (discharge velocity × maximum grain size)/μ

(ii) (actual velocity × average grain size)/ν

(iii) (discharge velocity × average grain size)/ν

(iv) (discharge velocity × pore size)/ν

(i) In one-dimensional flow in an unconfined aquifer between two water bodies, when there is a recharge, the water table profile is

(i) a parabola

(ii) part of an ellipse

(iii) a straight line

(iv) an arc of a circle

(j) The discharge per unit drawdown at a well is known as

(i) specific yield

(ii) specific storage

(iii) safe yield

(iv) specific capacity

2. (a) Define groundwater hydrology. Why do we study groundwater hydrology? 6

(b) Discuss different types of geological formation. What are the differences between confined and unconfined aquifers? 8

(f) The unit of intrinsic permeability is

(i) cm/day

(ii) m/day

(iii) darcy/day

(iv) cm^2

(g) The dimensions of the storage coefficient S are

(i) L^2/T

(ii) $L^3 T^2$

(iii) L/T^2

(iv) Dimensionless

(h) The surface joining the static levels in several non-pumping wells penetrating a continuous confined aquifer represents

(i) water table surface

(ii) capillary fringe

(iii) physical top surface of the aquifer

(iv) piezometric surface of the aquifer

3. *(a)* State Darcy's law of flow in porous medium and its limitations. 5

(b) Three wells *A*, *B* and *C* tap the same horizontal aquifer. The distances *AB* = 1200 m and *BC* = 1000 m. The well *B* is exactly south of well *A* and the well *C* lies to the west of well *B*. The following are the ground surface elevation and depth of water below the ground surface in the three wells.

Well	*Surface elevation* (m above datum)	*Depth of water table* (m)
A	200·0	11·0
B	197·0	7·0
C	202·0	14·0

Determine the direction of groundwater flow in the aquifer in the area *ABC* of the wells. 9

4. *(a)* Define the terms—specific yield, storage coefficient and transmissibility. 6

(b) Determine the storage coefficient of an aquifer having porosity = 30%, thickness of aquifer = 25 m, bulk modulus of compression = 2·1 GN/m^2 and modulus of elasticity of the soil skeleton = $3 \times 108 N/m^2$. 8

5. What are Dupit's assumptions? Starting from an elementary prism of fluid bounded by a water table, derive the steady one-dimensional unconfined groundwater flow equation with a recharge rate *R*. 14

6. *(a)* Discuss the principle of recuperation test of an open well. 6

(b) During a recuperation test, the water in an open well as depressed by pumping by 2·5 m, it recuperated 1·8 m in 80 minutes. Calculate the yield from a well of 4·0 m diameter under a depression head of 3·0 m.

7. *(a)* Explain the terms with neat sketch—cone of depression, drawdown, and radius of influence. 6

(b) Derive the equation for steady radial flow into a well in confined aquifer. 8

8. A 20 cm diameter tube well taps an artesian aquifer. Find the yield for a drawdown of 3·0 m at the well. The length of the strainer is 30 m and the coefficient of permeability of the aquifer is 35 m/day. Assume the radius of influence as 300 m. If all other conditions remain same, find the percentage change in yield if *(a)* the diameter of the well is 40 cm, *(b)* the drawdown is 6·0 m and *(c)* permeability is 17·5m/day. 14

9. Write short notes on the following :

   (a) Safe yield of an aquifer

   (b) Well loss

   (c) Recharge of groundwater

   (d) Groundwater assessment

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Code : 011855

B.Tech. 8th Semester Exam., 2017

Ground Water Engineering

Time : 3 hours *Full Marks : 70*

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **Nine** questions in this paper.*

*(iii) Attempt **Five** questions in all.*

(iv) Questions No. 1 is compulsory.

1. Answer any seven questions from the following: 14

i) An aquifer confined at the bottom but not at the top is called

(a) semiconfined aquifer

(b) unconfined aquifer

(c) confined aquifer

(d) perched aquifer

ii) Flowing artesian wells are expected in areas where

(a) the water table is very close to the land surface

(b) the aquifer is confined

(c) the elevation of the piezometric head line is above the elevation of the ground surface

(d) the rainfall is intense

iii) The annual ground water storage in an area is equal to

(a) land area x drop in ground water table

(b) land area x rise inground water table x porosity of formation

(c) involved area of aquifer x maximum seasonal fluctuation in ground water table x specific yield of aquifer

iv) Water present in artesian aquifers is usually

(a) at sub-atmospheric pressure

(b) at atmospheric pressure

(c) at 0.5 times the atmospheric pressure

(d) above atmospheric pressure

v) The permeability of a soil sample at the standard temperature of 20°C was 0.01 cm/s. The permeability of the same material at a flow temperature of 10°C is in cm/s

(a) <0.01

(b) >0.01

(c) =0.01

(d) depends upon the porous material

(vi) For laminar flow in a medium sand aquifer, the Reynolds number is

(a) <2000

(b) < 1

(c) 1 to 10

(d) < 500

vii) What would be the volume stored in a saturated column of aquifer with a porosity of 0.35, cross-sectional area of 1 square metre and of 3.0 metres depth?

(a) 3.0 m^3

(b) 2.0 m^3

(c) 1.05 m^3

(d) 0.105 m^3

viii) When there is an increase in the atmospheric pressure, the water level in a well penetrating a confined aquifer

(a) decreases

(b) increases

(c) does not undergo any change

(d) increases or decreases depending upon the elevation of the ground

(ix) For one-dimensional flow without recharge in an unconfined aquifer between two water bodies, the steady water table profile is

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(a) a parabola

(b) an ellipse

(c) a straight line

(d) an arc of a circle

x) The specific capacity of a well in confined aquifer under equilibrium conditions and within the working limits of drawdown

(a) can be taken as constant

(b) decreases as the drawdown increases

(c) Increases as the drawdown increases

(d) increases or decreases depending upon the size of the well

2. (a) Explain the Darcy's Experimental Law. 5

(b) An extensive aquifer is known to have a ground water flow in N 30° E direction. Three wells A, B and C are drilled to tap this aquifer. The well B is to East of A and the well C is to North of A. The following are the data regarding these wells:

Distance (m)	Well Surface	Elevation (m above datum)	Elevation of water table (m)
	A	170.0	167.0
AB = 600 m	B	169.0	166.5
AC=1800 m	C	168.0	?

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Estimate the elevation of water table at well C when the wells are not pumping. 9

3. Why do we need groundwater investigation? Explain the electrical resistivity method of groundwater exploration along with Wenner and Schlumberger configurations. Describe the merit and demerits of electrical resistivity and seismic methods of goundwater exploration. 14

4. (a) Define the terms : Specific yield, Specific retention, Storage coefficient and Permeability. 6

   (b) In a phreatic aquifer extending over 1 km^2, the water table was initially at 25 m below ground level. Some times after irrigation with a depth of 20 cm of water, the water table rose to a depth of 24 m b.g.I. Later 3×10^5 m^3 of water was pumped out and the water table dropped to 26.2 m b.g.I. Determine (i) specific yield of the aquifer, (ii) deficit in soil moisture (below field capacity) before irrigation. 8

5. (a) Define the compressibility of Aquifers and derive the equation for the specific storage. 7

   (b) Derive the basic differential equation for confined ground water flow. 7

6. Develop the equation relating the steady-state discharge from a well in an unconfined aquifer and depths of water table at two known positions from the well. State clearly all the assumptions involved in your derivation. 14

7. Two rivers A and B run parallel to each other and fully penetrate the unconfined aquifer situated on a horizontal impervious base. The rivers are 4.0 km apart and the aquifer has a permeability of 1.5 m/day. In a year, the average water surface elevation of the rivers A and B, measures above the horizontal impermeable bed, are 12.0 m and 9.0 m respectively. If the region between the rivers received an annual net infiltration of 20 cm in that year, estimate (a) the location of the groundwater table divide and (b) the average daily groundwater discharge into the rivers A and B from the aquifer between them. 14

8. What do you mean by conjunctive use of surface and groundwater? Explain. What are benefits of conjunctive use, and why is it essential for countries such as India? What are portable water standards of WHO? 14

9. Write short notes on four of the following: 14

   i. Safe yield of an aquifer

   ii. Recuperation Test

iii. Well loss

iv. Subsurface Zones

v. Recharge of groundwater

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Institute / College Name :	**DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA**		
Program Name	**B.Tech. CIVIL**		
Course Code	CE 011855		
Course Name	Ground Water Engineering		
Lecture / Tutorial (per week):	3/0	**Course Credits**	3
Course Coordinator Name	**Mr. Ahsan Rabbani**		

1. Textbooks

TB1: Ground water Hydrology by M. H. Raghunath, New Age Publication, New Delhi.
TB2: Irrigation Engineering and Hydraulic Structures by Sahasrabuddhe. S. R., Katson, Ludhiana, 1975

2. Reference Books

RB1: 'Ground Water Hydrology' by Todd, David Keith (2007), Wiley India Edition, New Delhi – 110002.

Other readings and relevant websites

S.No.	**Link of Journals, Magazines, websites and Research Papers**
1.	http://nptel.ac.in/courses/105103026/#
2.	http://www.hwe.org.ps/Education/Birzeit/GroundwaterEngineering/GroundwaterEngineering.aspx
3.	http://civilengineeringmcq.com/2017/06/1016/

4. Course Plan

Lecture Number	Date of Lecture	Topics	Web Links for video lectures	Text Book / Reference Book / Other reading material	Page numbers of Text Book(s)
1-8		**Introduction**		TB2, RB1	
		Ground water development in India. Characteristics of fluid and the Medium. Soil moisture, Classification of subsurface water, Darey's law, Range of validity of Darey's law, Co-efficient of permeability.	https://www.youtube.com/watch?v=TcLL0Oy0zUA https://www.youtube.com/watch?v=7TuXeoaf6u4		
9-18					
		General Hydro-dynamical Equations for the flow of Fluids through Porous media. The Equation of continuity, Equation of motion, Dupuit's equations for unconfined seepage flow, Plane free surface flow with horizontal impervious base without infiltration. Plane free surface flow with horizontal impervious boundary with infiltration and evaporation. Confined and semi-confined flow.	https://www.youtube.com/watch?v=jvro3iopTGo https://www.youtube.com/watch?v=udKOVtJoe-s https://www.youtube.com/watch?v=ZvsSe5sJGdc	TB1, RB1	

Assignment I					
19-25					
		Mechanics of Flow towards Well aquifers, Classification. Specific yield, Storage co-efficient, Land susidence due to ground water withdrawals, unconfined wells. Discharge of an ordinary perfect well as a function drawdown.	https://www.youtube.com/watch?v=20fK4kCD-pU https://www.youtube.com/watch?v=MAQtkXKjwzw	TB1, RB1	
Mid-Semester Exam (Syllabus covered from 1-16 lectures)					
26-32					
		Unconfined flow towards well with uniform infiltration from the ground surface. Confined radial flow towards the well. Discharge as a function of drawdown, well efficiency, Radius of influence, Determination of permeability by one or two well methods.	https://www.youtube.com/watch?v=udKOVtJoe-s&t=43s https://www.youtube.com/watch?v=Gf3mW9xlcw4 https://www.youtube.com/watch?v=AOWjiXXkUcc	TB1, RB1	
33-35		Lowering of ground water table, Unsteady confined flow, Well losses.	https://www.youtube.com/watch?v=udKOVtJoe-s&t=96s https://www.youtube.com/watch?v=AOWjiXXkUcc&t=26s	TB1, RB1	
36-37		Geophysical Investigations Surfacegeophysical techniques, Electrical resistivity, Seismic refraction and reflection, other methods.	https://www.youtube.com/watch?v=hYk30I_-LxY	TB1, RB1	
Assignment 2					
38-40				TB1, RB1	
		Ground Water Quality :Water sampling, Potable water standards of WHO, Ground Water Basin Management and Conjuctive Use of Surface and Ground Water A case study, Investigation design, construction and maintenance of tube, wells, filter materials and education wells.	https://www.youtube.com/watch?v=4uck3FucIv0 https://www.youtube.com/watch?v=-ad_WLKgA1A		

1. **Evaluation Scheme:**

Component 1	Mid Semester Exam	15
Component 2	Assignment Evaluation	15
Component 3**	End Term Examination**	70
	Total	**100**

****** The End Term Comprehensive examination will be held at the end of semester. The mandatory requirement of 75% attendance in all theory classes is to be met for being eligible to appear in this component.

SYLLABUS

Topics	No of lectures	Weightage
Ground water development in India. Characteristics of fluid and the Medium. Soil moisture, Classification of subsurface water, Darey's law, Range of validity of Darey's law, Co-efficient of permeability.	8	15%
General Hydro-dynamical Equations for the flow of Fluids through Porous media. The Equation of continuity, Equation of motion, Dupuit's equations for unconfined seepage flow, Plane free surface flow with horizontal impervious base without infiltration. Plane free surface flow with horizontal impervious boundary with infiltration and evaporation. Confined and semi-confined flow.	9	20%
Mechanics of Flow towards Well aquifers, Classification. Specific yield, Storage co-efficient, Land susidence due to ground water withdrawals, unconfined wells. Discharge of an ordinary perfect well as a function drawdown	7	20%
Unconfined flow towards well with uniform infiltration from the ground surface. Confined radial flow towards the well. Discharge as a function of drawdown, well efficiency, Radius of influence, Determination of permeability by one or two well methods.	8	20%
Lowering of ground water table, Unsteady confined flow, Well losses	5	15%
Geophysical Investigations Surfacegeophysical techniques, Electrical resistivity, Seismic refraction and reflection, other methods.	4	5%
Ground Water Quality :Water sampling, Potable water standards of WHO, Ground Water Basin Management and Conjuctive Use of Surface and Ground Water A case study, Investigation design, construction and maintenance of tube, wells, filter materials and education wells.	4	5 %

This Document is approved by:

Designation	Name	Signature
Course Coordinator	Mr. Ahsan Rabbani	
H.O.D	Mr. S.S Choudhary	