CE 3620 WATER RESOURCES ENGINEERING

Lecture (MWF): 12:05 - 12:55 DOW 642
Lab (T): Dillman 110
INSTRUCTOR INFORMATION

Dr. Veronica L. Webster, Associate Professor

- Office: Dillman 201D
- Telephone: 487-1079
- E-mail: vlweb@mtu.edu
- Office Hours: Tuesday 2:00 – 4:00 pm
  Thursday 9:00 – 11:00 am

**Stated hours are times I am guaranteed to be in my office and available. However, I have an open door policy, so feel free to stop by whenever my door is open. Appointments may also be made as needed, and I am always available via email.**
**COURSE DESCRIPTION/OVERVIEW**

- **Introduction to hydrologic engineering**
  - Watershed hydrology
  - Rainfall-runoff modeling
  - Hydrologic frequency analysis

- **Analysis and design of hydraulic systems**
  - Pipe networks
  - Storm water management systems
  - Open channel hydraulics
  - Hydrologic routing

- **Weekly lab sessions** help students visualize and reinforce concepts covered in lecture.
COURSE RESOURCES

- **Required Course Text:**
  

- **Course Websites:**

  Canvas  <http://mtu.instructure.com/login>
  
  - *Canvas will be used only to maintain course grades and to distribute homework solutions.*

  Personal Website
  
  <http://www.cee.mtu.edu/~vlweb/ce3620.html>
  
  - *Schedule changes, practice exams, lecture handouts, lab handouts, etc. will be posted on my personal website.*
COURSE GRADES

Course grades will be computed based on:

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework assignments (11)</td>
<td>30</td>
</tr>
<tr>
<td>Laboratory</td>
<td>30</td>
</tr>
<tr>
<td>Mid-term Exams (2)</td>
<td>20</td>
</tr>
<tr>
<td>Final Exam</td>
<td>15</td>
</tr>
</tbody>
</table>

Grades will be assigned approximately* as follows:
- 93-100 A; 88-92 AB; 83-87 B; 78-82 BC;
- 73-77 C; 68-72 CD; 61-67 D; 0-60 F.

(*The scale may be adjusted downward, but it will not be adjusted upward.)
HOMEWORK ASSIGNMENTS

- **Due at the beginning of class** on the day listed in schedule. Grades for late homework reduced by **10 points for each 24-hour period it is late.**

- For full credit, **all work must be shown**—do not just give the answer. Assignments must be **neat, legible, and follow a logical order.**

- Assignments not done on a computer must be submitted on **engineering paper.** No loose leaf, spiral notebook, or any other type of paper will be accepted.

- Students are encouraged to work together on homework problems, however, each student is required to submit his/her own solution for each problem set.
LABORATORY SESSIONS

- In first part of course, there will be 6 experimental labs. Although work in groups during lab sessions, calculations and written lab reports are **to be completed individually**.

- In second part of course, lab sessions used to explain tasks required for team project. Weekly memos and final project report to be **completed as a team**.

- **Each lab report/memo due at start of your next scheduled lab session**, unless otherwise indicated by TA or Dr. Webster. Lab TAs will provide additional details on format and grading of lab reports. *(See lab syllabus)*
LABORATORY SESSIONS

Jennie Tyrrell (jltyrrel@mtu.edu)
Office: 813 DOW
Office Hours: 2:00-4:00 pm MF

Sara Mille (sgmille@mtu.edu)
Office: 856 DOW
Office Hours: 8 – Noon Thursday

**Email for appointment**
# Laboratory Sessions (Dillman 110)

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/1</td>
<td>No Lab Meetings</td>
</tr>
<tr>
<td>9/8</td>
<td>Lab 1: Flow Measurement</td>
</tr>
<tr>
<td>9/15</td>
<td>Lab 2: Venturi Meter</td>
</tr>
<tr>
<td>9/22</td>
<td>Lab 3: Pumps in Series &amp; Pumps in Parallel</td>
</tr>
<tr>
<td>9/29</td>
<td>No Lab Meetings (Career Fair)</td>
</tr>
<tr>
<td>10/6</td>
<td>Lab 4: Headloss Along a Pipe and at Fittings</td>
</tr>
<tr>
<td>10/13</td>
<td>Lab 5: Open Channel Flow – Experimental Design</td>
</tr>
<tr>
<td>10/20</td>
<td>Lab 6: Open Channel Flow – Flume</td>
</tr>
</tbody>
</table>

NOTE: No labs first week of class or week of Career Fair.
## Laboratory Sessions (Computer Lab - TBA)

<table>
<thead>
<tr>
<th>Week</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/27</td>
<td>Task 1: Watershed Delineation</td>
</tr>
<tr>
<td>11/3</td>
<td>Task 2: Watershed Characteristics</td>
</tr>
<tr>
<td>11/10</td>
<td>Task 3: Hydrologic Frequency Analysis and Hydrologic Models</td>
</tr>
<tr>
<td>11/17</td>
<td><strong>No Lab Meetings</strong></td>
</tr>
<tr>
<td>12/1</td>
<td>Task 4: Geographical Information Systems</td>
</tr>
<tr>
<td>12/8</td>
<td>Project Presentations (<strong>DOW 873</strong>)</td>
</tr>
</tbody>
</table>

*Project Report Due by 5 pm, 12/11*
LABORATORY SESSIONS

- Lab handouts containing background information and directions for each lab session will be posted on the course website at least one week in advance. **Students are expected to read the lab handout prior to the start of lab.**

- **Attendance in your registered lab section is mandatory.**

- **Each lab report/memo will be due at the start of your next scheduled lab session,** unless otherwise indicated.

- Grades for reports/memos submitted late will be reduced by **20% for each day late.**

- **All lab reports/memos must be prepared using a computer.**
EXAMS

There will be two in-class mid-term exams, each covering approximately 5 weeks of material, and a comprehensive final exam given during finals week.

• Midterms:
  Friday, October 9
  Wednesday, November 18

• Final Exam: TBA
EXAMS

- **All exams will be closed book/notes.** However, you may bring a one-page crib sheet (8.5” x 11”, front and back) to each mid-term exam; two sheets may be brought to the final exam.

- **There will be no make-up exams.** In the event of pre-meditated absences, for such reasons as university-sponsored activities or family emergency, Dr. Webster should be notified as early as possible. Exams may be given prior to absence.
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Problem Set: Problems (Due)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M, 8/31</td>
<td>Intro. to water resources engineering</td>
<td>1.1-1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T, 9/1</td>
<td><em>No Lab Meetings</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W, 9/2</td>
<td>Hydrologic cycle &amp; watershed hydrology</td>
<td>2.1-2.5</td>
<td>A: 2.1, 2.2, 2.4, 2.5, 2.8, 2.10</td>
</tr>
<tr>
<td></td>
<td>F, 9/4</td>
<td>Streamflow &amp; other water quantity units</td>
<td>2.6-2.7</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>M, 9/7</td>
<td><em>No Class – Labor Day</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T, 9/8</td>
<td><em>Lab 1: Flow Measurement</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W, 9/9</td>
<td>Fluid mechanics review</td>
<td>3.1-3.4, 3.7</td>
<td>B: 3.10</td>
</tr>
<tr>
<td></td>
<td>F, 9/11</td>
<td><em>No Class – K Day Recess</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>M, 9/14</td>
<td>Steady flow hydraulics</td>
<td>4.1</td>
<td>B: 4.5, 4.6 (<em>A due</em>)</td>
</tr>
<tr>
<td></td>
<td>T, 9/15</td>
<td><em>Lab 2: Venturi Meter</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W, 9/16</td>
<td>Pumps in pipelines</td>
<td>4.2</td>
<td>C: 4.7, 4.10</td>
</tr>
<tr>
<td></td>
<td>F, 9/18</td>
<td>Culverts</td>
<td>4.3</td>
<td>C: 4.4, 4.16</td>
</tr>
<tr>
<td>4</td>
<td>M, 9/21</td>
<td>Pipelines in series vs. parallel</td>
<td>4.4</td>
<td>D: 4.21, 4.25 (<em>B due</em>)</td>
</tr>
</tbody>
</table>
WHAT IS WATER RESOURCES ENGINEERING?

- Control/Management of Water
  - Flood Damage Reduction/Mitigation
  - Stormwater Management/Culvert Design

- Utilization of Water (CE5666)
  - Water Supply – Industrial, Municipal, Agricultural
  - Hydroelectric Power Generation
  - Navigation
  - Recreation

- Protection of water resources and environment
  - Water pollution control
  - Land use management (floodplain)
  - Stream Restoration, Erosion Control, Dam Removal (CE5665)
QUESTIONS TO BE ANSWERED IN DESIGN

- How much water is needed?
- How much water can be expected?
- What size structure is needed?
- Who may use the water?
- What kind of water is it?
- What structural problems exist?
- How is the natural environment affected?
- Is the project economically efficient and equitable?
ASSOCIATED DISCIPLINES

- Civil & Environmental Engineers
- Geologists
- Electrical & Mechanical Engineers
- Economists
- Political Scientists
- Chemists and Biologists
- Other natural and social scientists
VARIOUS TOPICS

- Hydrology (rainfall, runoff, evaporation, etc.)
- Stormwater drainage
- Sewer/pipeline design
- Water distribution systems
- Groundwater
- River flooding and sedimentation
- Structures in water (dams, culverts, intakes)
- Watershed management
THE HYDROLOGIC CYCLE
STORMWATER DRAINAGE

http://deltrac.org/stormwater/description.shtml
**Stormwater Drainage**

- Drain stormwater runoff (or reduce it) to prevent flooding
- Engineers help plan development and design pipe sizes and slopes, pond sizes, outlet structures, and vegetation.

**CE4640: Stormwater Management & LID**

*Water Resource Engineering*, by Ralph A. Wurbs & Wesley P. James
Copyright © 2002 by Prentice-Hall, Inc. All rights reserved.
SEWERS & PIPELINES

- Need pipes to carry away wastewater/stormwater runoff [sanitary, storm or combined]
- Need large pipes to carry water and oil long distances (e.g. Alaska pipeline).
- Engineers design pipe size, material, layout, route, supports, etc.
WATER SUPPLY & DISTRIBUTION SYSTEMS

- Municipal/Industrial water supply.
- Complicated network of hundreds of miles of pipe underground.
- Design pipe sizes, pumps, tanks, etc.

- ENVE4507: Water Distribution and Wastewater Collection Design
GROUNDWATER

- Groundwater is a major source for many purposes
- What size pumps and how deep of a well?
- Where does water flow under ground?

- GE3850: Geohydrology
- GE4800: Groundwater Engineering
RIVER FLOODING AND SEDIMENTATION

- Predict if and when flooding will occur.
- Find required height of levee.
- Determine when to evacuate people.

- CE4620: River & Floodplain Hydraulics
- CE5620: Stochastic Hydrology
- CE5665: Stream Restoration
- CE5666: Water Resources Planning & Management
GRAND RAPIDS, MI, AUGUST 2013

http://photos.mlive.com/mlivecom_photo_essays/2013/04/20_most_dramatic_images_from_h.html#incart_m-rpt-2
FLOODPLAIN MANAGEMENT

- Regulate development in floodplains
- How is extent of floodplain determined?
- For what magnitude flood flow?
HURRICANE IRENE
VERMONT
AUGUST 2010

http://www.mansfieldheliflight.com/flood/
Flood Prediction

- Given measured rainfall values, predict magnitude of streamflow at watershed outlet
- Analyze impact of urbanization and/or channel modification on streamflow at watershed outlet
$Q = \text{stream discharge}$

Hydrograph

$Q$ vs. Time
FLOOD MITIGATION: DETENTION BASIN

Figure 10.7 Runoff hydrographs before and after development.
STRUCTURES IN WATER: DAMS/RESERVOIRS

- Dams provide for storage, water supply, flood control.
- Can collect sediment and disrupt fish passage.
- Design outlet structures (pipes, spillway)

STRUCTURES IN WATER: CULVERTS

- Culverts carry water under roads to prevent disruption of traffic or erosion.
- Engineers design opening, size, material, erosion control, fish passage.

CE4620: River & Floodplain Hydraulics
EROSION/
BANK INSTABILITY

BRIDGE SCOUR

- CE5665: Stream Restoration
- CE4620: River & Floodplain Hydraulics

LARGE SCALE SYSTEMS: RESERVOIR OPERATIONS

- CE5666: Water Resources Planning & Management
A Delicate Balance

Balance is the key to management of the Tennessee River system. Six carefully balanced public benefits are taken into account. If you maximize only one, you do so at the expense of the others.

The above chart illustrates TVA’s six areas of responsibility. Move your cursor over the sections to read more.

Click to maximize one of the benefits, and see how that choice affects the rest of the system

- **LAND USE**
  - Sensitive natural resources are protected.

- **RECREATION**
  - Conditions for recreational boating improve.

- **WATER QUALITY**
  - Higher flow rates improve aquatic habitat.

- **POWER SUPPLY**
  - Output from nuclear and fossil plants is reduced due to lack of water supply for cooling.

- **NAVIGATION**
  - Speed of barge transportation on the river increases.

- **FLOOD CONTROL**
  - Potential for flood damage increases; waterfront development is restricted.

To rebalance system, click here
GREAT LAKES

- Navigation
- Hydropower generation
- Flood reduction
WATERSHED MANAGEMENT

- Movement of pollutants with water
  - Nonpoint sources (i.e. agriculture)
  - Point sources (i.e. wastewater treatment/stormwater drainage)
- Sedimentation, stream restoration

- ENVE4505: Surface Water Quality Engineering
- ENVE5504: Surface Water Quality Modeling
CLIMATE CHANGE/LAND USE CHANGE

Observed trend in annual maximum flood flows → Cause??
How is the design flow impacted?

Source: Kashelikar & Griffis (2008) EWRI Proceedings

- CE5620: Stochastic Hydrology