CHAPTER 0. CONSTRUCTION EQUIPMENT AND METHODS

Course Syllabus

TA & GRADER:
Name: to be added and revised
Office Hours: M 2:00 pm – 3:15 pm
Room: EGR 1107
Telephone: (123) 123-4567
Email: TA@domain.com


REFERENCES:
2. “Modern Construction & Ground Engineering Equipment & Methods,” by Harris, F., 1994. Also, Instructor’s Notes and Handouts.

GRADING: HW (20%), Midterm Exam (25%), Final Exam (30%), Project (20%), and Quizzes (5%).
Course Syllabus

PREREQUISITES:
• ENCE 320, Permission of Department
• Senior Standing

COURSE WEBSITE:

GENERAL COURSE DESCRIPTION (UM SCHEDULE OF CLASSES):
ENCE420 Construction Equipment and Methods; (3 credits) Grade Method: REG/P-F/AUD. Prerequisite: ENCE 320 and permission of department. Senior standing. Evaluation and selection of equipment and methods for construction of projects, including earthmoving, paving, steel and concrete construction, formwork, trenching, cofferdams, rock excavation, tunneling, site preparation and organization. Design of formwork, trench supports, and cofferdams.

Course Syllabus

COURSE OUTLINE & SCHEDULE:

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<tr>
<th>Week</th>
<th>Date</th>
<th>Topic of Discussion</th>
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<tbody>
<tr>
<td>1</td>
<td>W, Jan. 29</td>
<td>Introduction to Course (General Overview)</td>
<td>Chapter 1</td>
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<td>2</td>
<td>M, Feb. 3</td>
<td>Introduction</td>
<td>Chapter 1</td>
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<td></td>
<td>W, Feb. 5</td>
<td>Equipment Cost</td>
<td>Chapter 3</td>
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<td>3</td>
<td>M, Feb. 10</td>
<td>Equipment Cost (cont’d)</td>
<td>Chapter 3</td>
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<td>W, Feb. 12</td>
<td>Geotechnical Materials</td>
<td>Chapter 4</td>
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<td>4</td>
<td>M, Feb. 17</td>
<td>Geotechnical Materials (cont’d)</td>
<td>Chapter 4</td>
</tr>
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<td></td>
<td>W, Feb. 19</td>
<td>Compaction and Stabilization</td>
<td>Chapter 4</td>
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<tr>
<td>5</td>
<td>M, Feb. 24</td>
<td>Compaction and Stabilization (cont’d)</td>
<td>Chapter 4</td>
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<td>W, Feb. 26</td>
<td>Machine Power</td>
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## Course Syllabus

### COURSE OUTLINE & SCHEDULE (cont’d):

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<tr>
<td>6</td>
<td>M, Mar. 3</td>
<td>Dozers</td>
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<td></td>
<td>W, Mar. 5</td>
<td>Scrapers</td>
<td>Chapter 7</td>
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<td>7</td>
<td>M, Mar. 10</td>
<td>Excavators</td>
<td>Chapter 8</td>
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<td></td>
<td>W, Mar. 12</td>
<td>Finishing Equipment</td>
<td>Chapter 9</td>
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<td>8</td>
<td>M, Mar. 17</td>
<td>Trucks and Hauling Equipment</td>
<td>Chapter 10</td>
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<td>W, Mar. 19</td>
<td>MIDTERM EXAM</td>
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<td>Mar. 24-30</td>
<td>**** SPRING BREAK (NO CLASSES) ****</td>
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<tr>
<td>9</td>
<td>M, Mar. 31</td>
<td>Trucks and Hauling Equipment</td>
<td>Chapter 10</td>
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<td></td>
<td>W, Apr. 2</td>
<td>Compressed Air</td>
<td>Chapter 11</td>
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<th>Week</th>
<th>Date</th>
<th>Topic of Discussion</th>
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<tr>
<td>10</td>
<td>M, Apr. 7</td>
<td>Compressed Air</td>
<td>Chapter 11</td>
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<tr>
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<td>W, Apr. 9</td>
<td>Drilling Rock and Earth</td>
<td>Chapter 12</td>
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<tr>
<td>11</td>
<td>M, Apr. 14</td>
<td>Drilling Rock and Earth</td>
<td>Chapter 12</td>
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<td></td>
<td>W, Apr. 16</td>
<td>Blasting Rock</td>
<td>Chapter 13</td>
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<td>12</td>
<td>M, Apr. 21</td>
<td>Aggregate Production</td>
<td>Chapter 14</td>
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<td>W, Apr. 23</td>
<td>Cranes</td>
<td>Chapter 17</td>
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<td>13</td>
<td>M, Apr. 28</td>
<td>Draglines and Clamshells</td>
<td>Chapter 18</td>
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<td></td>
<td>W, Apr. 30</td>
<td>Piles and pile-Driving Equipment</td>
<td>Chapter 19</td>
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## COURSE SYLLABUS

### HOMEWORK ASSIGNMENTS:
Professional presentation of homework assignments is required. Professional presentation consists of neat and organized solution of problems on one side of 8.5”x11” papers. Any homework not complying with professional standards will not be graded and will be assigned zero credit. The homework assignments are due one week after they are assigned. Homework will be assigned as the material is covered and will be collected every Monday at the beginning of the lecture period. Assignments turned in late will be docked 10% for each day it is late past the original due date. Solutions will be available from the TAs and on the class website after the problems are returned. No assignment will be accepted after the answers have been posted. Students are encouraged to discuss and formulate solutions to the problems by working in teams. However, assignments must be completed and submitted individually. Simply copying the answers from another student or from a solutions manual is not acceptable and will not be tolerated.

### COURSE OUTLINE & SCHEDULE (cont’d):

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<th>Topic of Discussion</th>
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<tr>
<td>14</td>
<td>M, May 5</td>
<td>Equipment for Pumping Water</td>
<td>Chapter 20 Handout</td>
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<td>W, May 7</td>
<td>Belt-Conveyor Systems + Review</td>
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<td>15</td>
<td>M, May 12</td>
<td>Project Presentations (Groups 1, 2, 3, and 4)</td>
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<tr>
<td></td>
<td>W, May 14</td>
<td>Project Presentations (Groups 5, 6, and 7)</td>
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<td>16</td>
<td>Tu, May 20</td>
<td>FINAL EXAM (Tuesday, 1:30 pm – 3:30 pm, CHM (0119))</td>
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EXAMS:
All students must take all exams including the final exam. Only extenuating circumstances will be accepted as excuse for missing an exam. Health related excuses require medical reports and the signature of a physician that provided treatment.

PROJECT (Term Paper): To be announced and discussed.
Objectives

“Learn how to apply engineering fundamentals and analyses to the planning, selection, and utilization of construction equipment.”

Engineering Concepts

This course uses concepts from various engineering disciplines:

- Engineering Economics
- Geotechnical Engineering (Soil Mechanics)
- Mechanical Engineering (Construction Equipment)
- Structural Engineering
- Environmental Engineering
- Others
Underlying Concepts

Construction of engineered facilities requires the utilization of construction equipment.

Purpose of the Course

Learn to apply engineering fundamentals and analyses to the planning, selection, and utilization of construction equipment.

Through understanding of:

(1) The total construction process, from inspection of the idea through construction and start up, and

(2) How construction equipment should be selected and used to produce the intended quality in the most cost-effective manner.
CHAPTER 0. CONSTRUCTION EQUIPMENT AND METHODS

Course Outline & Topics

Introduction (Chapter 1)

- Construction Contracts
  - Lump-sum contract
  - Unit-price contract
  - Cost-plus-fee contract
- Performance Guarantee
  - Contractor is to furnish a performance bond for a project
- The Time Value of Money
  - Money has a time value.
  - One dollar today is worth more than $1 tomorrow.
  - Failure to pay the bills results in additional charge.

Course Outline & Topics

- Discounted Present Worth Analysis
- Rate of Return Analysis
- Equipment Planning and Estimating
Course Outline & Topics

Equipment Cost (Chapter 3)

• Equipment cost rank second to labor. Machines and equipment can be:
  • Purchased
  • Leased
  • Rented (short time)
• The Cost of Construction Equipment
  • Ownership Cost
  • Depreciation
  • Operating Cost (maintenance, repairs, fuel, etc..)
• Economic Life of Engineering Equipment

Course Outline & Topics

The Planning Process for Equipment and Methods

• Planning process for equipment and methods is necessary both prior to and during the actual construction of a project
• The planning is required for:
  • Production
  • Achievement
  • Cost Control
  • Coordination of the project and the parties involved in the project
Course Outline & Topics

• Formal Planning involves the following steps:
  • Analysis of a Project (Time, Money, Location, etc.)
  • Identification Project Activities
  • Estimate of cost, time, resources to perform each activity
  • Development of Plan Network
  • Application of Realistic Limitations to activities

Course Outline & Topics

Geotechnical Materials, Compaction, and Stabilization (Chapter 4)

“Persons in a construction industry, including constructors (contractors) and engineers, should understand the affects of which the selection of equipment and method have on the cost of handling these materials”
Course Outline & Topics

- Material Properties:
  - The actual construction process of any project is really a material-handling problem.
  - On heavy construction projects the major portion of the work consists of handling and processing bulk materials.
- Excavation
  - Common Excavation
  - Rock Excavation (drilling and blasting)
  - Muck Excavation (soft organic material)
  - Unclassified excavation (materials that cannot be defined as soil or rock)

Soil mass weight and volume relationships

\[
\begin{align*}
\text{Weight air} &= 0 \\
\text{Weight water} &= W_w \\
\text{Weight soil solids} &= W_s \\
\text{Total weight} W &= \text{Weight water} + \text{Weight soil solids} \\
\text{Total volume} V &= \text{Volume air} + \text{Volume water} + \text{Volume soil solids}
\end{align*}
\]
Course Outline & Topics

Soil mass weight and volume relationships

- Unit weight ($\gamma$) = total weight of soil/total soil volume = $W/V$
- Dry unit weight ($\gamma_d$) = weight of soil solids/total soil volume = $W_s/V$
- Water content ($\omega$) = weight of water in soil/weight of soil solids = $W/W_s$
- Void ratio ($e$) = volume of voids/volume of soil solids = $V_v/V_s$
- Porosity ($n$) = volume of voids/total soil volume = $V_v/V$
- Specific gravity ($G_s$) = weight of soil solids/volume of solids/unit weight of water = $W_s/V_s/\gamma_w$

Total soil volume ($V$) = volume voids ($V_v$) + volume solids ($V_s$)

Weight of solids ($W_s$) = weight of soil ($W$)/(1+water content ($\omega$))

or

$\gamma_d = \gamma/(1+\omega)$

Compaction and Soil Stabilization

- Soils are the principal component of many construction projects.
- Soils are used to support:
  - structures - static load
  - pavements for highways and airport runways - dynamic loads
  - dams and levees, as impoundment - to resist the passage of water.
- Some soils may be suitable for use in their natural state, whereas other, must be excavated, processed, and compacted in order to serve their purposes.
- Knowledge of the properties, characteristics, and behavior of different soil types is important to those persons who are associated with the design or construction of projects involving the use of soils.
- R. R. Proctor initiated a scientific study to determine the density-moisture relationship of soils.
Course Outline & Topics

- Machine Power (Chapter 5)

- **Rimpull**
  - The usable power at the point of contact between the tire and the ground for a wheel machine.

- **Drawbar Pull**
  - The available usable power (pull) which a crawler tractor can exert on a load that is being towed.

\[
F_w = \frac{33,000 \times fwhp \times E}{v}
\]
Dozers and Tractors (Chapter 6)

• **Tractors** are self-contained units that are designed to provide tractive power for drawbar work.
• Consistent with their purpose as a unit for drawbar work, they are low center of gravity machines. This is a prerequisite of a good machine.
• The larger the difference between the line-of-force transmission from the machine and the line of resisting force the less effective the utilization of developed power.
• Typical project applications are land clearing, bulldozing, ripping, and towing other pieces of construction equipment.
Course Outline & Topics

Scrapers (Chapter 7)

- Tractor-pulled scrapers are designed to load, haul, and dump loose materials.
- The advantage of tractor-scraper combinations is their versatility.
- They can be used in a wide range of material types (including shot rock) and are economical over a wide range of haul lengths and haul conditions.
Excavators (Chapter 8)

• Excavating equipment is used to excavate earth and rock in construction operations.
• The equipment includes the following machines:
  1. Draglines
  2. Clamshells
  3. Hydraulic excavators
     a. Front shovels
     b. Hoes
  4. Loaders
     a. Wheel
     b. Track
  5. Trenching machines

Finishing Equipment (Chapter 9)

Rollers
Trucks and Hauling Equipment (Chapter 10)

- Trucks may be classified according to a number of factors including:
  1. The size and type of engine - gasoline, diesel, butane, propane
  2. The number of gears
  3. The kind of drive - two-wheel, four-wheel, six-wheel, etc.
  4. The number of wheels and axles and arrangement of driving wheels
  5. The method of dumping the load - rear-clump, side-dump
  6. The class of material hauled - earth, rock, coal, ore, etc.
  7. The capacity, in tons or cubic yards

Compressed Air (Chapter 11)

- Compressed air is used extensively on construction projects for:
  - Drilling rock
  - Loosening earth
  - Operating air motors
  - Hand tools
  - Pile drivers
  - Pumps
  - Mucking equipment
  - Cleaning.
Drilling Rock and Earth (Chapter 12)

• Drilling equipment and methods are used by the construction and mining industries to drill holes in both rock and earth.
• Purposes for which drilling are performed vary a great deal from general to highly specialized applications.
• It is desirable to select the equipment and methods that are best suited to the specific service:
Course Outline & Topics

Blasting Rock (Chapter 13)

- Blasting" is performed to break rock so that it may be quarried for processing in an aggregate production operation, or to excavate a right-of-way.
- Blasting is accomplished by discharging an explosive that has either been placed in an unconfined manner, such as mud capping boulders, or is confined as in a borehole.

Course Outline & Topics

The Production of Crushed-Stones Aggregates (Chapter 14)

- The production of crushed-stone aggregate involves:
  - Drilling,
  - Blasting,
  - Loading,
  - Transporting,
  - Crushing,
  - Screening, and
  - Product handling and storage.
Cranes (Chapter 17)

- Cranes are a broad class of construction equipment used to hoist and place loads.
- Each type of crane is designed and manufactured to work economically in a specific site situation.
- The most common types are:
  1. Crawler
  2. Hydraulic truck
  3. Lattice-boom truck
  4. Rough-terrain
  5. All-terrain
  6. Heavy lift
  7. Modified cranes for heavy lift
  8. Tower
Excavating equipment is used to excavate earth and rock in construction operations.

The equipment includes the following machines:

1. Draglines
2. Clamshells
3. Hydraulic excavators
   a. Front shovels
   b. Hoes
4. Loaders
   a. Wheel
   b. Track
5. Trenching machines
Course Outline & Topics

Piles and Pile-Driving Equipment (Chapter 19)

- Load-bearing piles, are used primarily to transmit structural loads, through soil formations with poor supporting properties, into or onto soil strata that are capable of supporting the loads.
Course Outline & Topics

Equipment for Pumping Water (Chapter 20)

Pumps are used extensively on construction projects for:
1. Removing water from pits, tunnels, and other excavations.
2. Dewatering cofferdams.
3. Furnishing water for jetting and sluicing.
4. Furnishing water for many types of utility services.
5. Lowering the water table for excavations.
6. Foundation grouting.

Belt- Conveyor Systems (Handout)

- Belt-conveyor systems are used extensively in the field of construction.
- Belt-conveyor systems frequently provide the most satisfactory and economical method of handling and transporting materials, such as earth, sand, gravel, crushed stone, mine ores, cement, concrete, etc.
- Because of the continuous flow of materials at relatively high speeds, belt conveyors have high capacities.

Note: During the construction of the Channel Tunnel (between England and France) conveyors were used to move up to 2,400 tons of spoil per hour from the tunnel headings.