CS/ME 6754, COA 8676E
Design & Engineering Information Technology

Course Notes - Working Draft

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Instructors:
Dr. Robert E. Fulton
Dr. Angela Y. Birkes

About this Document
This is a living online document that evolves with the course. New sections may be added, and existing sections may be revised. Students will be notified of relevant changes. As a supplement to the lectures and other course material, these notes do not contain the full course content.

Available at Course Web Page:
http://www.eislab.gatech.edu/courses/me6754/spr01/

Access to Course Material
This document and other online instructor materials are for access only by students in this course unless permission is obtained from the instructor.

Revisions

8/21/00	Initiated with course scope (section 2)
10/1/00	Developed framework and the following sections: 1 Course Material Index (for online pdf files, etc.) 3 Some Information Technology Terminology 4 Process Modeling (IDEF0) 5 Design & Engineering Examples: PWA & PWB Information Integration (1990 MARC Report) 7 Getting Started With Oracle 8 Assignment and Exam Information
10/17/00	Added link to project description and to HW3 solution notes
01/07/01	Revised for Spring 2001
01/11/01	HW set #2 Added for Spring 2001
01/17/01	HW set #3 Added for Spring 2001
01/18/01	HW set #4 Added for Spring 2001
01/30/01	HW set #5 Added for Spring 2001
02/01/01	HW set #6 Added for Spring 2001
02/07/01	HW set #7 Added for Spring 2001
02/12/01	HW set #8 & #9 Added for Spring 2001
03/11/01	HW set #10 Added for Spring 2001
03/14/01	HW set #11, 12, & 13 Added for Spring 2001

Contents

1 Course Material Index

The primary course material is given here. Other resources may be referenced in specific sections of these notes.

E&M
Fundamentals of Database Systems, Third Edition by R. Elmasri & S. Navathe, Addison-Wesley (2000).

This is the primary text for the course.

Kemper
Object-Oriented Database Management: Applications in Engineering and Computer Science by A. Kemper and G. Moerkotte, Prentice-Hall (1994).

Chapters 1, 2, and 4 are available at:
http://www.eislab.gatech.edu/courses/me6754/resources/1994-kemper.pdf

Eastman
Building Product Models by C. Eastman, CRC Press (1999).

Chapters 5-6, which cover ISO STEP technologies, are available at:
http://www.eislab.gatech.edu/courses/me6754/resources/1999-eastman.pdf

F&C
ME6754 Engineering Data Management Course Notes by R. Fulton and B. Chadha (1999)

Available at:
http://www.eislab.gatech.edu/courses/me6754/resources/1999-fulton/

2 Course Scope

CS/ME 6754, COA 8676E
Design & Engineering Information Technology

August 21, 2000

Surveys techniques and practice of:

- Representing design and engineering "objects" in a computable manner

  Informally:
  "object" = information structure + operations and properties
  computable representation = "object" modeling languages (textual and graphical)
  + representation properties + methodologies

- Implementation and usage in collaborative computing environments

Emphasizes context for the design and engineering of physical systems:
aircraft, automobiles, bridges, buildings, electronics, machines, ships, etc.

Analogous to AI survey course (plus more design and engineering specialization):
CS 6705 Applications of Artificial Intelligence

2.1 Related Courses

- This section approximates the context of this course with respect to other courses

2.1.1 General Techniques (from Computer Science)

- Generally these courses cover the topics of this course in more detail (as well as other topics)
- They are analogous to math courses that engineers take as a basis for engineering topics
  Example: *math:* differential equations → *engineering:* continuum mechanics

CS 2340 Objects and Design
CS 7610 Modeling and Design

CS 4400 Introduction to Database Systems
CS 4420 Database System Implementation
CS 4440 Emerging Database Technologies and Applications
CS 6400 Database Systems Concepts and Design
CS 6411 Object-Oriented Database Models and Systems
CS 6421 Active and Dynamic Database Management Systems
CS 6430 Parallel and Distributed Database Systems and Applications

CS 4432 Information Systems Design

CS 4600 Introduction to Intelligent Systems
CS 4610 Knowledge Systems

CS 7210 Distributed Computing
CS 7460 Collaborative Computing

2.1.2 Application Domains

- The below lists are for the Architecture & Mechanical Engineering domains.
- Similar lists could be given for other domains of engineering and design.

2.1.2.1 Domain Objects

- These are the kinds of objects the domain deals with (independent of any computer implementation)

COA 8645 Analytical Models of Built Space and Its Functions
COA 8650 Formal Descriptions of Designs: Analyses of Space, Shape
COA 8680 Performance Aspects of Building Systems Design
etc.

ME 6441 Dynamics of Mechanical Systems
ME 6442 Vibration of Mechanical Systems
ME 7228 Thermo-Mechanical Reliability in Electronic Packaging
ME 7203 Advanced Constitutive Relations for Solids
etc.

2.1.2.2 Domain-Oriented Representations & Environments

- These are domain-oriented ways to represent the above objects in a computable form (usually by adapting and applying the general computer science techniques from the previous section)
- This course looks at these topics from a generalized perspective with respect to their usage in collaborative computing environments

COA 8670 Design of Design Environments
COA 8678 Geometric Modeling Software Development for Architecture
COA 8690 Integrated Design and Engineering Environments for Buildings
COA 8674 Structuring Multimedia Design Knowledge
etc.

ME 4041 Interactive Computer Graphics and Computer-Aided Design
ME 6104 Computer-Aided Design
ME 6124 Finite-Element Method: Theory and Practice
ME 6758 Numerical Methods in Mechanical Engineering
etc.

3 Some Information Technology Terminology

The below come from http://www.britannica.com/ as of 8/29/00 unless otherwise noted.

information systems

The primary vehicles for the purposeful, orchestrated processing of information are information systems--constructs that collect, organize, store, process, and display information in all its forms (raw data, interpreted data, knowledge, and expertise) and formats (text, video, and voice). In principle, any record-keeping system--e.g., an address book or a train schedule--may be regarded as an information system. What sets modern information systems apart is their electronic dimension, which permits extremely fast, automated manipulation of digitally stored data and their transformation from and to analog representation.

...

The database has become a central organizing framework for many information systems, taking advantage of the concept of data independence, which allows data sharing among diverse applications. Database management system (DBMS) software today incorporates high-level programming facilities that do not require one to specify in detail how the data should be processed.

information system n : the network of all communication channels used within an organization [syn: data system]
Source: WordNet ® 1.6, © 1997 Princeton University

information science

A discipline that deals with the processes of storing and transferring information. It attempts to bring together concepts and methods from various disciplines such as library science, computer science and engineering, linguistics, psychology, and other technologies in order to develop techniques and devices to aid in the handling--that is, in the collection, organization, storage, retrieval, interpretation, and use--of information.

science

Any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws.

technology

The application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment. The development over time of systematic techniques for making and doing things.

engineering

The application of science to the optimum conversion of the resources of nature to the uses of humankind. The field has been defined by the Engineers Council for Professional Development, in the United States, as the creative application of "scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property." The term engineering is sometimes more loosely defined, especially in Great Britain, as the manufacture or assembly of engines, machine tools, and machine parts.

database

Any collection of data, or information, that is specially organized for rapid search and retrieval by a computer. Databases are structured to facilitate the storage, retrieval, modification, and deletion of data in conjunction with various data-processing operations.

4 Process Modeling

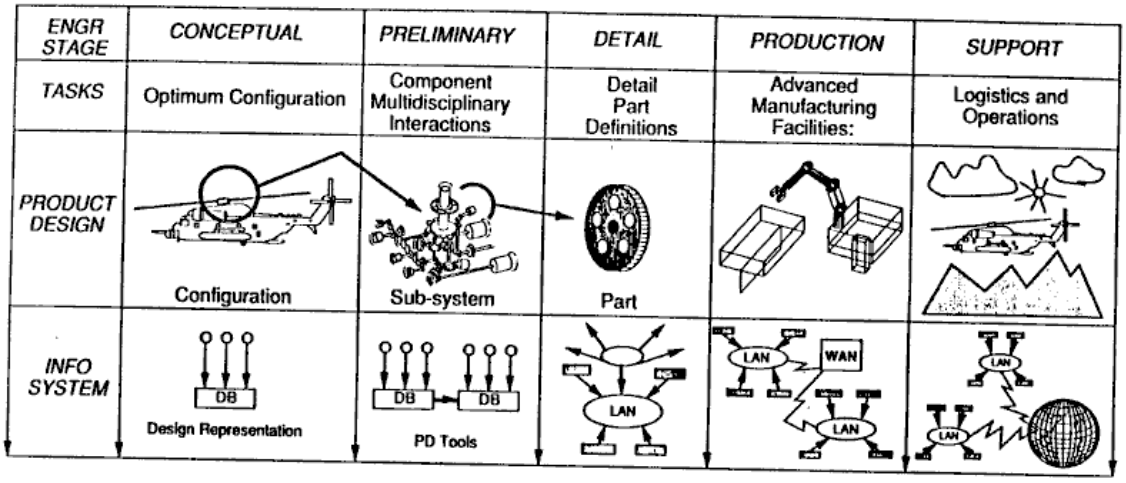
4.1 IDEF0

AECRC slides:
http://www.eislab.gatech.edu/courses/me6754/resources/1999-aecrc-idef0.pdf

F&C: Section 5.8 and figures at end of Section 5. (see Course Material section)

PWA example in Section 5.

5 Design & Engineering Examples



Product Information Throughout the Life Cycle
[Fig 1.2 from Fulton & Chadha ME 6754 course notes]

5.1 PWA & PWB Information Integration (1990 MARC Report)

Multidisciplinary Approach to Printed Wiring Board Design by Fulton et al., Georgia Tech Mfg. Research Center (MARC) Report (1990).

Selected portions are available at:
http://www.eislab.gatech.edu/pubs/reports/1990-marc-fulton/

Contents relevant to this course include:

- Chapter 1-3 - Problem context
- Section 4.5 - Engineering information management issues
  - Figure 4.5-5 - Multidisciplinary views of a resistor
- Chapter 9 - Description of a prototype engineering information integration framework (TSET)
  - Figure 9.1-1 - Information system architecture
  - Figure 9.3-3 - Database design process
- Chapter 11 - References
- Appendices
  - B - IDEF0 process model
  - C - IDEF1X and ER information models and basic data dictionary
  - D - Representative PWA/B datasets and implementation as Oracle tables
  - E - Queries and results on Oracle implementation

6 Information Modeling Tools

See http://www.methods-tools.com/ for tools that aid creation and implementation of information models. For example, MS Visio Professional 2000 contains tools for ER, EXPRESS, and UML.

7 Getting Started with Oracle

Adapted from Spring'99 notes by M. C. Ramesh

7.1 Introduction

Oracle is a Relational Database Management System (RDBMS). With an RDBMS, one can implement a relation information model in a computing system. Operations include: create tables and insert, update and delete data (rows) from these tables. You can also query the tables to get a subset of the data that you want. Apart from this, one can assign security permissions to the tables, create indexes to speed up data retrieval. All this is just a small subset of Oracle's capabilities, but they are the most important ones for the course.

SQLPlus is the interactive command line interface of ORACLE. In SQLPlus, you can enter commands one at a time, or you can run script files which contain many commands.

7.2 Using Oracle on acme

1. Log into your GT account on `acme.gatech.edu` using `telnet` or `ssh` (as part of the campus PRISM system - see www.oit.gatech.edu for further details). Here `acme` may actually be `acmex`, `acmey`, or `acmez`.
2. Enter the command "`. oraenv`" to initialize the Oracle environment (note the space between `.` and `oraenv`).
3. At the "`ORACLE_SID = [username] ?`" prompt enter "`public`".
4. Enter the command "`sqlplus /`" to begin using the public database.

For further assistance, please contact the Customer Support Center at 404-894-7173 or send email to support@oit.gatech.edu.

Here is an example session for user gt1234a:

```
{acmex:gt1234a:142} . oraenv
ORACLE_SID = [gt1234a] ? public
{acmex:gt1234a:143} sqlplus /

SQL*Plus: Release 8.1.6.0.0 - Production on Wed Sep 13 16:34:57 2000

(c) Copyright 1999 Oracle Corporation.  All rights reserved.


Connected to:
Oracle8i Enterprise Edition Release 8.1.6.0.0 - Production
With the Partitioning option
JServer Release 8.1.6.0.0 - Production

SQL>
```

Once you receive the `SQL>` prompt, its fairly certain your setup is working properly.

7.3 Oracle Documentation

Here are some resources for SQL and Oracle documentation.

0. Chapters 8 and 10 of E&N for basic SQL and Oracle.

1. http://www.eislab.gatech.edu/courses/me6754/resources/oracle-sql.pdf
This overviews SQL in Oracle with examples. It may be a little old (before SQL2?), but the basics should be similar.

2. http://gromit.oit.gatech.edu/~ks43/ORACLE/O7.html
This is for Oracle 7 (vs. Oracle 8 on acme), but the basics should be the same/similar.

3. http://cbt.training.gatech.edu/cbtweb/curicula/sqpl.htm
(plus others at http://cbt.training.gatech.edu/cbtweb/curicula/oracle8i.htm)

This is a self-paced-style introduction for Oracle 8i. See the SQL portions if needed.

4. http://technet.oracle.com/
You must register before you can access the documents. However, the membership is free.

5. See the PWA examples in the 1990 MARC report by Fulton et al. references in the Design and Engineering Examples section of this document. It includes examples of moderately complex queries (Appendix E).

7.4 Some Useful Oracle Commands

Examples or data you substitute is included in these commands in <angle brackets>.

1. To get out of SQLPlus type:
SQL> **quit**

2. To get a top-level list of help topics, type:
SQL> **help**

3. To get help on a particular command type 'help' and then and then name of the command.
SQL> **help** <command>

4. To redirect and store the input and output from a SQLPlus session to a text file, type:
SQL> **spool** <filename>
(e.g., `spool myoutput.txt`)
To turn off spooling, type:
SQL> **spool off**
This is particularly useful for capturing database schema information and query results to turn in as homework and project documentation.

5. To display the structure of a table, type:

SQL> **desc** <table name>

Note: There may be equivalent commands for the whole schema -- let me know if you find one.

See E&M Section 10.3.2 for other Oracle data dictionary facilities (for listing meta-data).

6. To run commands in batch from a text file, type:
SQL> **start** <my-file.txt> ?)

This is the recommended approach for smaller problems like the class homework sets and projects. It enables you to more easily debug and rebuild your database in an incremental, iterative fashion.

To load instance data in batch, run a file that uses the **load data** command - see the manual entry for details.

Note: **load data** *used to work in older Oracle versions -- We could not find a similar command yet, so just use a series of* **insert** *commands if all else fails. Let us know if you find a way, or if you find errors in the above or other useful commands.*

Hint: Start your main schema creation file with this command to clean out any old table definitions and data (to avoid conflicts):
drop schema <my schema> **cascade**

Note: **create schema** *does not appear to work as in the book -- so you may have to drop each table separately. See the sample below.*

7.5 Sample SQL Command File

```
/*
This is a sample Oracle SQL command file.  Place it into a file called oracle-test.txt if
it does not already exist.

Execute it from the SQL prompt as follows:

    SQL> start oracle-test.txt

created 10/2/00 - for ME 6754 et al.
*/

/*
turn on spooling to capture oracle interactions
*/

spool test-log.txt


/*
===== create sample schema
*/


/*
first clean out any older versions to avoid conflicts
*/

drop table test;
```

```
/*
create an example table
*/

create table test (a int, b varchar(20) );

desc test;


/*
===== populate with sample data
*/

insert into test (a,b) values
(1,'xx');

insert into test (a,b) values
(1,'x1');

insert into test (a,b) values
(2,'yy');

insert into test (a,b) values
(3,'zz');


/*
===== do sample query
*/

select * from test;

select *
from test
where a = 1;

/*
===== turn off session capture
*/
spool off
```

8 Getting Started with Tools for STEP Express/Part21

8.1 ST-Developer (STEP Tools Inc.)

Special thanks to STEP Tools Inc. (www.steptools.com) for allowing usage of their tools for academic course usage. *Note:* These tools shall not be used for non-course work (e.g., it shall not be used for sponsored research projects). Academic licenses may be purchased from STEP Tools Inc. for such additional usage.

8.1.1 Obtaining the Tools

A local copy of the installation version for this tool (and other STEP-related application goodies) can be found at here (or you can download from www.steptools.com - see below):

http://eislab.gatech.edu/tmp/step-apps

(see the readme.txt file)

Strong Recommendation: As preparation for the homework, install ST-Developer by two weeks before the homework is due, **get a license key**, and ensure your installation works and that *you can do basic examples (see below).*

See the TA if you need to borrow a CD with the above (return in 2 days or pass to a class mate so everyone has a chance). These are offered on a first-come first serve basis with no guarantee of availability -- at a minimum you need to download it yourself from the web.

8.1.2 Installing the Tools

The ST-Developer files can also be downloaded from STEP Tools Inc. :

http://www.steptools.com/products/stdev
from: ST-Developer v8 Evaluation Download [52meg]
Download takes ~35 minutes via the Tech connection

http://www.steptools.com/products/stviewer/cuttingedge.html

Basically you need to do these steps:

- install this first: stdev-v8-win-eval.zip
  - After unzipping the file, see the section in the readme.txt for detailed installation instructions
  - See especially the section in the readme.txt file entitled "REQUESTING A LICENSE KEY" -- this says how to get a key via registering on the web. I have arranged it so each member of the class can get a copy -- when you register via the web, tell them its for this class, and give them your gt email address so they can email the license key directly to you (it is machine-specific)

- stdev includes the basic viewer

- you can also install patches to the viewer for "cutting edge" STEP formats: AP210 and AP227 files.

8.1.3 Preparation Hints & Exercises

Here are some notes on things you should be able to do as preparation for the STEP Express homework. In that homework you will do similar things for the truss problem or equivalent.

You should obtain and install ST-Developer as above and learn how to create schemas (express files) and instances (part 21 files) two weeks or more before the homework is due.

ST-Developer has tools to check that the instances conform to the schema.

See online documentation that comes with the toolkit:

ST-Developer Tools Reference
Chapter 15: General STEP Conformance Checker

> "EXPRESS information models contain rules and constraints that that applications can use to test data sets for correctness. This prevents the propagation of incorrect data from one application to another.
>
> The STEP Conformance Checker can evaluate EXPRESS rules and constraints to verify databases defined by the STEP application protocols. It can examine every object in the database and determine whether it complies with the rules and constraints defined in the application protocol EXPRESS model."

Warning: Note that you will have to generate these system files for your specific schemas:

- data dictionary files (<schema>.rose) and precompiled parse data files

(see section 15.4)

As a **self-tutorial exercise**, try it with these cases:

a) existing schemas/instances that come with the tool (see express and stpfiles directories respectively)

For example, you should be able to load and check these files:

express model file (schema):
C:\steptools_8.0_eval\express\part203\p203.exp

part 21 model file (instances):
C:\steptools_8.0_eval\stpfiles\ap203\angle1.stp

This can take a while if rule checking is activated. See the output window for results (some errors are reported).

b) Create and check a simple schema and part 21 files on your own (e.g., the point, line, polyline example from class -

You should be able to capture the following as evidence of successfully loading schema(s) and instance(s). Here "output" means the log of messages displayed in the ST-Developer Control Panel transcript region (e.g., you can use the Copy/Clear buttons to cut and paste into your homework report).

a) After running "Express Compiler": ST-Developer output showing that this schema loaded properly.

b) After running "STEP Checker": ST-Developer output showing that instance(s) loaded properly (from one or more P21 files).

You can adapt the headers/footers of the sample files as a starting template for your test files. Try editing your .stp file to create a typo on purpose, and check that the tool catches the error.

Other Hints & Warnings

1) The examples from the class handout on Express have some syntax-like issues that ST-Developer does not handle well (or they are/may be errors in our Express -- we need to check further on this):
   a) Express key words should not be used as attribute names. For example: `end` and `length`. Rename these to something like `associated_length`.
   b) Do not use attribute names that are the same as the type of attribute.
      For example, use
      ```
      associated_point : point
      ```
      instead of
      ```
      point : point
      ```
2) The following passes the Express checker ok, but it does not work and causes invalid page faults when trying to load Part 21 files:
   ```
   TYPE DATE =  ARRAY[1:3] OF INTEGER;  END_TYPE;
   ```
3) asdasd

Part 21 files can in general be created in any text editor, but ST-STEP File Browser offers color-coding and hyperlinks.

ST-Viewer can display geometry and part structure for those files represent shape using STEP standard entities (e.g., AP203 files). Try this for the angle1.stp file above.

For extra insight, try this:

1. View C:\steptools_8.0_eval\stpfiles\ap203\block.stp in ST-Viewer to see its orignal cube shape.
2. Copy the file and edit the new one in a text editor like Notepad. Change all `CARTESIAN_POINT` values with -2.5 to -20.0.
3. Load the new file into ST-Viewer and note the change. What happened and why?

9 Assignment and Exam Information

Following the hyperlinks to access information about the homework sets, exams, and projects.

9.1 Homework Sets

9.1.1 HW 1-1 & 1-2 – Meta Data for Classroom Example and Truss Design

Assignment
Solution notes

9.1.2 HW 2-1 & 2-2 – IDEF0 for Taking A Course Process and Truss Design

Assignment
Solution notes

9.1.3 HW 3-1 & 3-2 – IDEF1x for Taking A Course Process and Truss Design

Assignment
Solution notes

9.1.4 HW 4-1, 4-2 & 4-3 – ER and EER Models for University Database and Truss Design

Assignment
Solution notes

9.1.5 HW 5-1 & 5-2 – RDBMS Implementation for University Database and Truss Design

Assignment
Solution notes

9.1.6 HW 6-1 & 6-2 – RDBMS Implementation #2 for University Database and Truss Design

Assignment
Solution notes

9.1.7 HW 7 (9-1, 9-2, 9-3) – IGES Assignment

Assignment
Solution notes

9.1.8 HW 8 (10-1) – Download ST-Developer

Assignment
Solution notes

9.1.9 HW 9 (11-1 & 11-2) – STEP Implementation for University Database and Truss Design

Assignment
Solution notes

9.1.10 HW 10 (12-1 & 12-2) – Part 21 file for University Database and Truss Design

Assignment
Solution notes

9.1.11 HW 11 (14-1 & 14-2) – UML model University Database and Truss Design

Assignment
Solution notes

9.1.12 HW 12 – Constrained Objects and Analysis Integration Reading Assignment

Assignment
Solution notes

9.1.13 HW 13 (17-1 - 17-6) – Constrained Objects and Analysis Integration

Assignment
Solution notes

9.2 Projects

Assignment

9.2.1 Information Systems Project

9.2.2 Literature Survey Project

9.3 Exams

9.3.1 Midterm

No information available yet.

9.3.2 Final

No information available yet.