Teaching & Learning Engineering: a tango

Course Learning Objectives

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Instructor Goals

Program Outcomes

Learning Objectives

(What should the students be able to do at the end of the course?)

Bloom's Taxonomy

Learning Activities

(How do my students learn best?)

Assessment

(What is acceptable evidence of learning?)

Abbot Lowell

Universities are full of knowledge;
The freshmen bring a little in
and the seniors take none away,
so knowledge accumulates.

Before you build a house…

Before you build a house…

- How big is the lot?
- How many people will live in it?
- Number of bedrooms?
- Number of baths?
- How big of a living / dining room?
- Office / library?
- Garden / balcony / patio / pool ?
- Garage?
- Environmentally friendly?

Before you build an airplane…

Mission Specification

- 555 passengers + luggage
- More comfort!
- Crew = 2
- Range = 5,000 n. mi.
- Cruising Speed: Mach = 0.85 (289 m/s)
- Ceiling = 43,000 ft
- Takeoff / Landing distance = 12,000 ft


SINGAPORE AIRLINES


BOEING BWB

Before you build a course ?

Course Learning Objectives

(Where do I want to take my students – intellectually, physically, emotionally ?)

Learning Activities

(How do I take them there?)

Assessment

(How will I know they have arrived?)

SESSION OBJECTIVES

- **Explain** why we need CLOs.
- **Discuss** 6 levels of Bloom's & Anderson's (revised) Taxonomy and how they relate to CLOs.
- **Define** appropriate, meaningful, and measurable CLOs for your course and/or
- **Evaluate** existing CLOs.

What is a Learning Objective?

It is an intent, communicated by a statement describing a proposed change in the learner – a statement of what learners are to be like when they have successfully completed a learning experience.

Robert Mager

Learning Objectives must:

- Describe what the learner will have to do when demonstrating that they have reached the objective. (where am I going?)
- Describe any conditions under which the learner will demonstrate their competence. (How shall I get there?)
- Indicate how the learner will be evaluated, or what constitutes acceptable performance. (How will I know I have arrived?)

Why bother ? Because, CLOs…

1. Facilitate course design:
   a. Critically evaluate the relative importance of topics and the allocation of instructional time per topic.
   b. Identify and eliminate extraneous course material.
   c. Design in-class activities, out of class assignments, projects, tests, etc.
   d. Exercise all levels of Bloom's Taxonomy.
2. Communicate effectively your expectations from the students.

Why bother ? Because, CLOs…

(cont.' d)

3. Provide a study guide for students.
4. Give a clear picture of what students should be able to do, if they pass the course:
   a. Important for instructors of follow up courses.
   b. Important for new instructors teaching the course for the 1st time.
5. Required by accreditation agencies (e.g. ABET, WASC)
3. Drive the course assessment.

Bloom's Taxonomies of Educational Objectives :

- **Cognitive** domain

  Intellectual outcomes including knowledge, understanding, thinking skills.

- **Affective** domain

  Emotional outcomes including interests, attitudes, appreciation.

- **Psychomotor** domain

  Motor skill outcomes including operating laboratory equipment, drafting, sports.

BLOOM'S REVISED TAXONOMY
COGNITIVE DOMAIN

Higher-order thinking

Create / Synthesize
Design a new product or process

Evaluate
Choose among alternatives;
justify choice using specified criteria

Analyze
Tackle open-ended problems
Make appropriate assumptions, create a model, select appropriate theory…

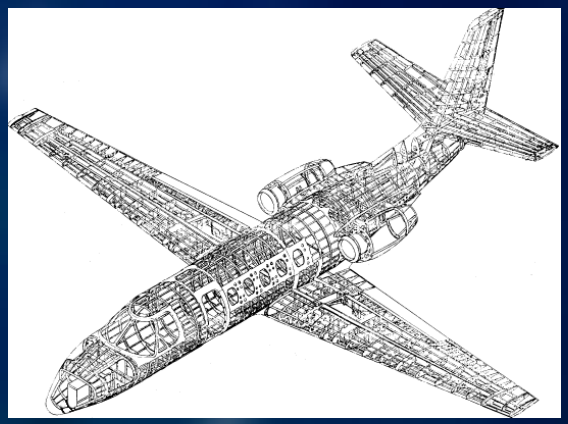
Apply
Use information in familiar situations
to solve problems

Understand
…the meaning of information: paraphrase, give examples...

Remember
Recall information

Level 1: Remember

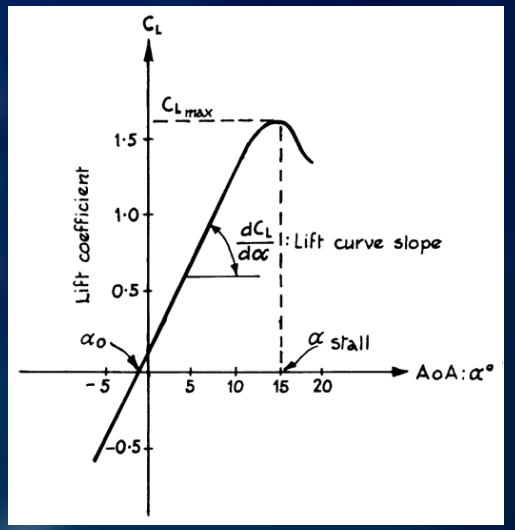
- **List** [the assumptions under which Bernoulli's equation is valid]
- **Identify** [all the components of an airplane structure]

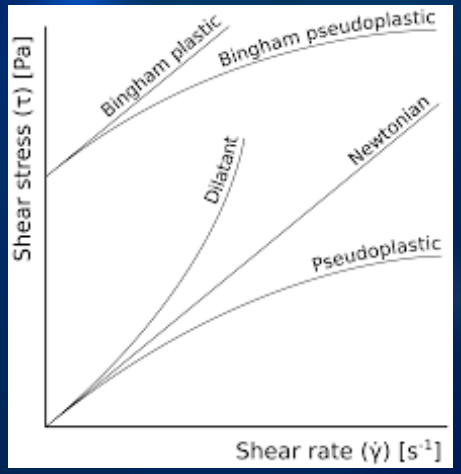


- **Outline** [the preliminary design process for an airplane]

Level 2: Understand

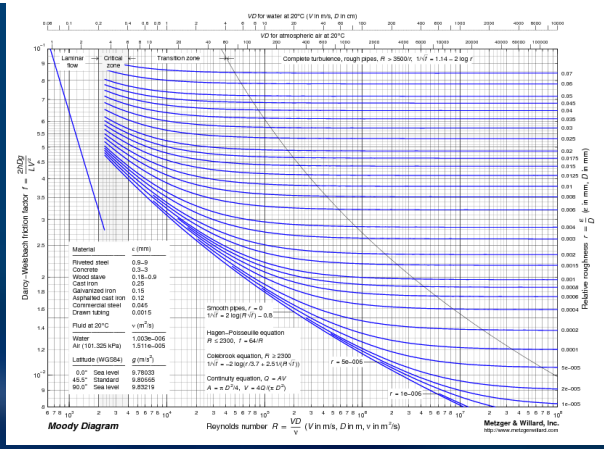
- **Explain** [in your own words how an airplane wing generates lift]
- **Describe** [the differences between liquids and gases and **explain** the origin of these differences]
- **Interpret** [the lift vs. angle-of-attack graph for an airfoil]
- **Distinguish** [between Newtonian and non-Newtonian fluids]



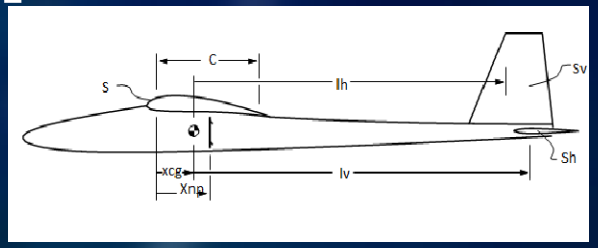


Level 3: Apply

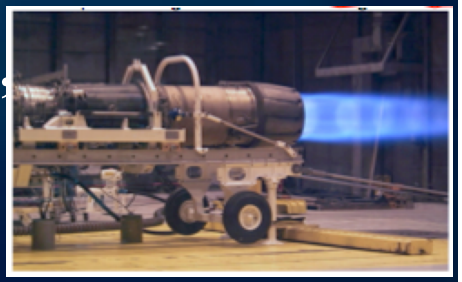
- **Use** [the Moody diagram to **solve** problems involving head losses in pipes].



- **Calculate** [the static margin of an airplane using the longitudinal stability equation].

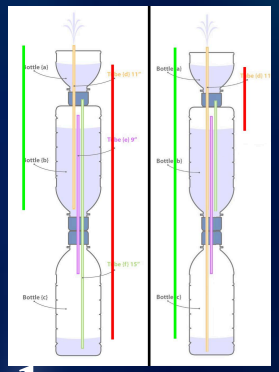


- **Apply** [the continuity equation to calculate velocities in a variety of cases involving 1-D, uniform, incompressible, steady flows].



Level 4: Analyze

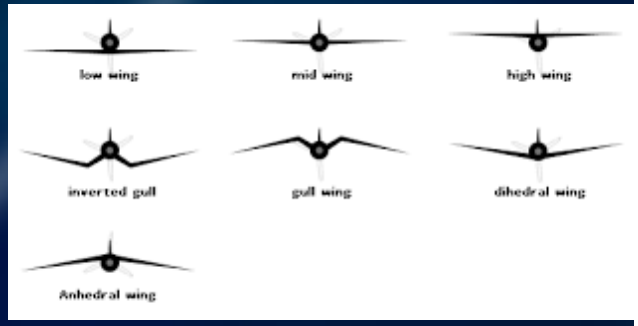
- **Derive** [the momentum equation for a fluid, starting with Newton's 2nd law of motion]
- **Explain** [how Hero's fountain works]



- **Analyze** [the aerodynamic interference for wings flying in the vicinity of each other]

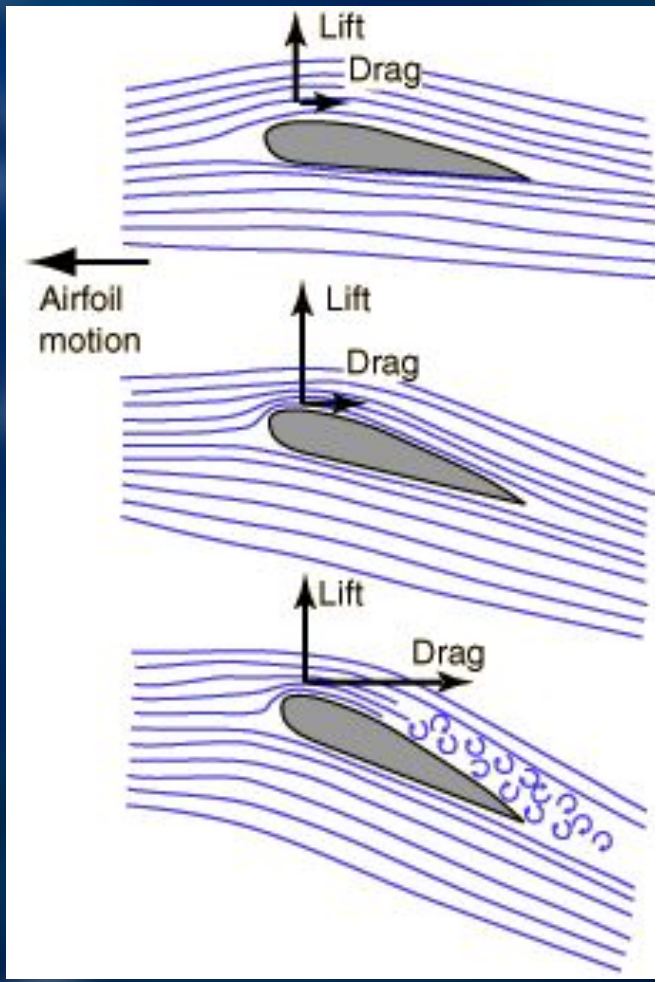
Level 5: Evaluate

- **Classify** [a flow as 1-D, 2-D, 3-D]
- **Optimize** [the weight distribution along the longitudinal axis, to result in a slightly unstable airplane]
- **Evaluate** [the available options for placing the wing on the fuselage], **select** [one of these options], and **justify** [your choice].



Level 6: Create

- **Identify, formulate and solve** [a problem involving the simultaneous application of continuity, momentum, and energy equations]
- **Design** [an experiment to verify the performance of the NACA 4412 airfoil, as shown in published data]
- **Create** [a flow chart to illustrate the process for calculating the pressure distribution on a swept wing in compressible flow]



CLO examples from an Aerodynamics course

Create	Design a wing for a supersonic executive jet.
Evaluate	Prepare a list of the design criteria for an airfoil to be used on the wing of an ultralight airplane.
Analyze	Use the method of images to analyze ground effects for an airfoil.
Apply	Use the SUB-2D program to explore the effects of thickness and camber on the aerodynamic characteristics (lift slope, aerodynamic center, etc.) of airfoils
Understand	Explain Kelvin's theorem and its implications for the vortex system of an airfoil. Explain induced drag in 5 different ways.
Remember	Define the following: (a) Mach number, (b) stagnation and critical conditions for isentropic flow, (c) stagnation and critical conditions for flow with heat addition

Examples of different level CLOs – Affective Domain

Characterized by a value or value complex	Always works independently and diligently, practices cooperation in group activities, acts ethically.
Organize	Recognizes the need to balance freedom and responsibility, formulates a career plan, adopts a systematic approach to problem solving and learning in general.
Value	Demonstrates a + attitude, appreciation, commitment through expression or action [I can solve this problem! I can design this airplane! It's actually fun! I really wan to win this competition; I will put my all into succeeding. Study above and beyond what is required to pass].
Respond	Shows interest in a subject, studies what is prescribed, carries out assignments.
Receive	Listens attentively in class, picks up handouts, visits course website.

Non-Instructional Objectives (Goals)

By the end of the course (Fluid Mechanics) you will:

- **Know** the basic principles of fluid mechanics (continuity, momentum, energy)
- **Learn** how an airplane flies.
- **Appreciate** blood flow through the human heart and capillaries.
- **Understand** fluids and how they differ from solids.


God's Commandments: the 1st draft
It's good... I like it... but I know these people...
(1) THOU SHALT NOT DO THINGS THAT ARE BAD.
(2) THOU SHALT BE NICE TO EACH OTHER.
...they're gonna want specifics!

Writing CLOs

By the end of this [course, section, week, lecture], students will be able to…(follow with an action verb).

- be as specific as possible
- be measurable
- address all levels of Bloom's Taxonomy (collectively), in a course.
  - ✓ Usually, only levels 1-3 are addressed.
  - ✓ Levels 4,5,6 require higher-order thinking skills.
  - ✓ Level 4: min required to have working knowledge of the material.

What is higher-order thinking?

A guide to ***Productive Pedagogies: Classroom reflection manual*** states that:

HoT by students involves the transformation of information and ideas. This transformation occurs when students combine facts and ideas and synthesize, generalize, explain, hypothesize or arrive at some conclusion or interpretation. Manipulating information and ideas through these processes allows students to solve problems, gain understanding and discover new meaning. When students engage in the construction of knowledge, an element of uncertainty is introduced into the instructional process and the outcomes are not always predictable; in other words, the teacher is not certain what the students will produce. In helping students become producers of knowledge, the teacher's main instructional task is to create activities or environments that allow them opportunities to engage in HoT.

(Department of Education, Queensland, 2002, p. 1)

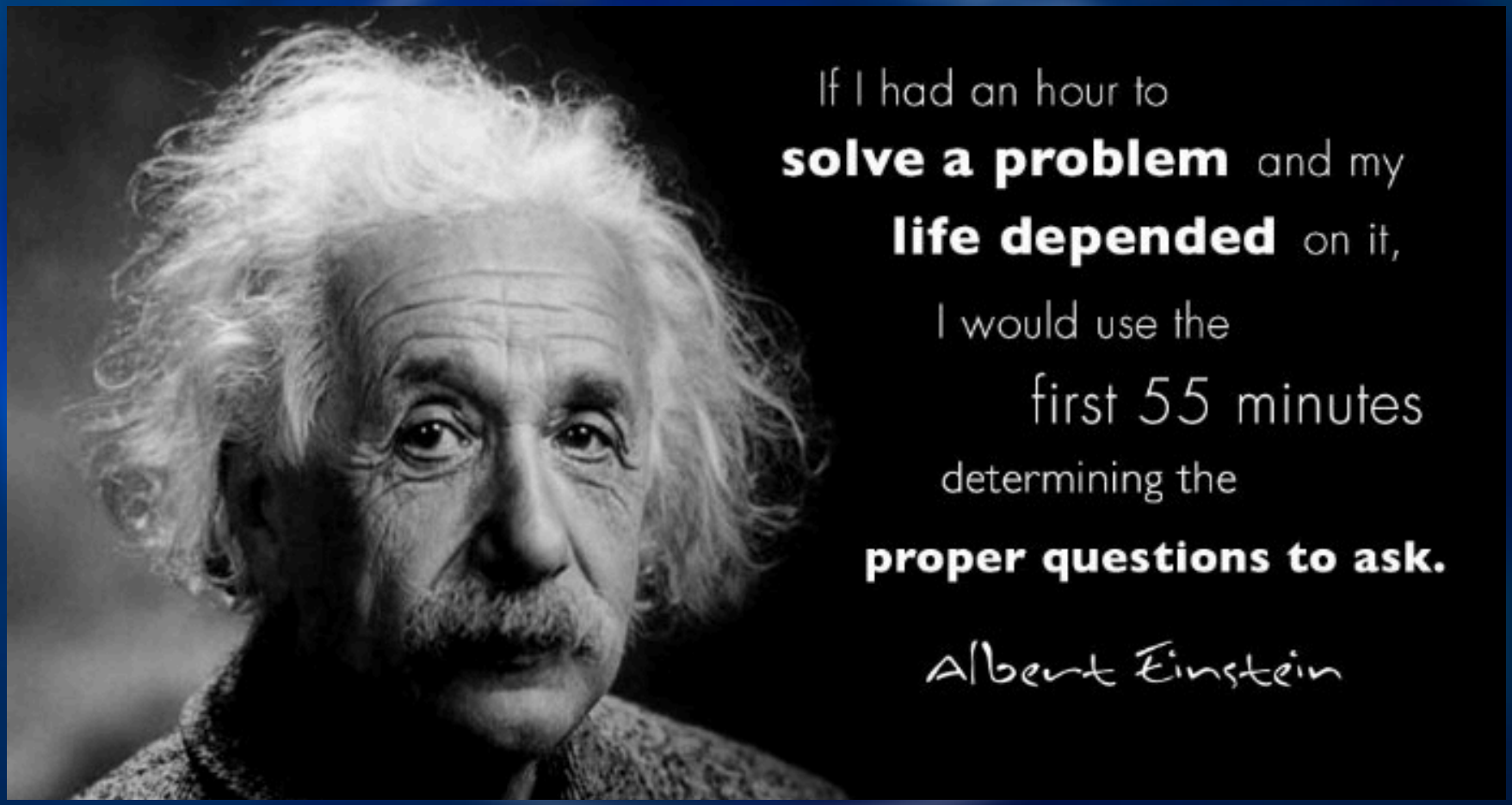
Individual Task – 5 min

- ***Evaluate the CLOs on the syllabus of your course***, i.e. determine the level of thinking required to complete this task using Bloom's Taxonomy.
- ***Estimate how much time*** you and your students must spend in class + outside of class to master each CLO.

Individual Task – 5 min

1. Select a topic in one of your courses.
2. What is the most difficult task you expect your students to be able to complete in this topic?
3. Write one or more CLOs that describe the skills related to this task.
4. Determine the level of thinking required to complete this task using Bloom's Taxonomy.
5. Make them clear and specific. Use action verbs like recall, explain, calculate, derive, design, select, justify, etc. Do not use "know", "learn", "appreciate", "understand".

Questions?


If I had an hour to
solve a problem and my
life depended on it,
I would use the
first 55 minutes
determining the
proper questions to ask.
Albert Einstein