BLOOM'S TAXONOMY

Topic	Following Bloom's Taxonomy to Assess Students
Summary	A handout for students to explain Bloom's taxonomy that is used for item writing and test construction to test students to see if they understand the course material at all levels – from knowledge to evaluation.
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Following Bloom's Taxonomy to Assess Students

Examinations are an integral part of taking most college courses. Only in a few courses such as Capstone Design or Independent Study would you not take an examination. Why do instructors use exams? One obvious function is assigning a course grades. Other less obvious but even more important reasons for using exams include

- ✓ Motivating students to learn and meet the objectives and goals of a course
- ✓ Provide feedback to students so that they know their weaknesses and strengths
- ✓ It also tells the instructors whether they are meeting their objectives

The purpose of this handout is to help you better prepare for exams by exploring the different types of questions that instructors formulate. To check your mastery at expected levels in the course – Computational Methods (Numerical Methods), I am following a widely used approach to item-writing and test construction. This approach is called Bloom's taxonomy. So, what is Bloom's taxonomy?

In 1956, an educational psychologist Benjamin Bloom was chairing a committee of higher education examiners who were asked to develop a system that would define whether students learned what they were taught. This system came to be known as Bloom's taxonomy.

In the cognitive domain, Bloom's taxonomy provides a guideline to develop test questions at levels of increasing competence as follows: knowledge → comprehension → application → analysis → synthesis → evaluation. But, what do these categories of competence mean? I am going to briefly explain each category, follow it by an example from the topic of Numerical Differentiation from the Computational Methods course, and then explain how the example fits the category. The examples given are multiple-choice but could be rephrased to be written as short answer, fill in the blanks or problem solutions.

1. **Knowledge** – This level checks for basic knowledge and memorization. It is simply recall of information or knowledge.
   Example:
   The definition of the first derivative of a function f(x) is
      a) $f'(x)=\frac{f(x+\Delta x)+f(x)}{\Delta x}$
      b) $f'(x)=\frac{f(x+\Delta x)-f(x)}{\Delta x}$
      c) $f'(x)=\lim_{\Delta x\to 0}\frac{f(x+\Delta x)+f(x)}{\Delta x}$
      d) $f'(x)=\lim_{\Delta x\to 0}\frac{f(x+\Delta x)-f(x)}{\Delta x}$

   Explanation:
   In this problem, I am asking you a question from the pre-requisite course of Calculus I. This formula is reintroduced in the Computational methods course to develop methods for numerical differentiation. The question simply checks whether you have memorized the definition of a derivative of a function.

2. **Comprehension** – This level checks for literal understanding and checks if you can apply the general concepts to a problem.
   Example:
   The exact derivative of f(x) = x^3 at x=5 is most nearly
      a) 25.00
      b) 75.00
      c) 106.25
      d) 125.00

   Explanation:
   In this problem, I am asking you to find the exact derivative of a function. You need to know how to find exact derivatives of simple functions to be later able to understand numerical differentiation methods and concept of true errors to show how well numerical differentiation works.

3. **Application** – This level checks whether you are able to use the concepts and apply them. These can be problems where you are asked to apply a numerical method to a simple problem.

Example:

Using forwarded divided difference with a step size of 0.2, the derivative of $f(x)=e^x$ at $x=2$ is

a) 6.697
b) 7.389
c) 7.438
d) 8.179

Explanation:

In this example, you are applying the one of three numerical methods you were taught in class to find the first derivative of a function.

4. **Analysis** – This level checks whether you can scrutinize a problem. You may be asked to examine a complex problem. To be able to solve it, you will have to break it into simpler parts. You should be able to see the connection between the parts.

   Example:

   A student finds the numerical value of $\frac{d}{dx}(e^x) = 20.219$ at $x=3$ using a step size of 0.2. Which of the following methods did the student use to conduct the differentiation?

   a) Backward divided difference
   b) Calculus, that is, exact
   c) Central divided difference
   d) Forward divided difference

   Explanation:

   In this example, you are now asked to find which method has been used. This involves being able to use the formulas of all the methods and see which one has been used. I can also assess whether you know the difference between the three numerical methods of finding the first derivative.

5. **Synthesis** – This level checks whether you can put concepts together to form a whole. One may need to use multiple pieces of information to be able to solve the problem.

   Example:

   Using backward divided difference scheme, $\frac{d}{dx}(e^x) = 4.3715$ at x=1.5 for a step size of 0.05. How many times would you have to halve the step size to the find $\frac{d}{dx}(e^x)$ at x=1.5 before two significant digits can be considered to be at least correct in your answer? You cannot use the exact value to determine the answer.

   a) 1

b) 2
c) 3
d) 4

Explanation:

Here, you are going to use the backward divided difference scheme several times. You need to synthesize the numerical differentiation results with your mastery of "Approximation and Errors" to see how many significant digits are at least correct in your answer. Therefore, this is an example of bringing several concepts together.

6. **Evaluation** – This is the level where you make a judgment. This is what you would be doing first when you apply the concepts learned in this course in another course or in a practical engineering or science problem. The factors you would consider to make a judgment in Computational Methods may be to reduce error, increase speed of computation, choose a particular method, make initial estimates, adopt step sizes, etc.

Example:

In a circuit with an inductor of inductance L and resistor with resistance R, and a variable voltage source E(t),

$$E(t) = L\frac{di}{dt} + Ri$$

The current, *i*, is measured at several values of time as

Time, t (secs)	1.00	1.01	1.03	1.1
Current, i (amperes)	3.10	3.12	3.18	3.24

If L= 0.98 Henries and R=0.142 ohms, how would you find E(1.00), what would be your choice for most accuracy.

a) $E(1) = 0.98(\frac{3.24 - 3.10}{0.1}) + (0.142)(3.10)$

b) $E(1) = 0.142 * 3.10$

c) $E(1) = 0.98 * \frac{3.12 - 3.10}{0.01} + 0.142 * 3.10$

d) $E(1) = 0.98 * \frac{3.12 - 3.10}{0.01}$

Explanation:

Here, the problem is not just finding the value of the derivative, but also how it is going to be used to eventually evaluate the voltage in a real-life problem. Also, you are asked to pick up the most accurate formula based on your current knowledge of numerical differentiation. Additionally, the data given is discrete and hence you do not have the luxury of having data at any point you desire, as is the case in derivatives of continuous functions.

Autar K Kaw of Mechanical Engineering and Jim Eison of Teaching Enhancement Center, both at the University of South Florida, wrote this handout. We hope that you are clear about the levels at which you will be tested. If you have any questions, please call Autar Kaw at 813-974-5626 or e-mail me at kaw@eng.usf.edu. Best of luck!

Appendix A – Questions for Nonlinear Equations

In this appendix, we give six sample questions for nonlinear equations. Find the right answer but also find out the motivation behind the incorrect answers as well.

1. Secant method of finding roots of nonlinear equations falls under the category of methods.

   A. bracketing
   B. graphical
   C. open
   D. random

2. The Newton-Rahpson method formula for finding the square root of a real number 'R' from the equation $x^2 - R = 0$ is,

   A. $x_{i+1} = \frac{x_i}{2}$
   B. $x_{i+1} = \frac{3x_i}{2}$
   C. $x_{i+1} = \frac{1}{2}\left(x_i + \frac{R}{x_i}\right)$
   D. $x_{i+1} = \frac{1}{2}\left(3x_i - \frac{R}{x_i}\right)$

3. Assuming an initial bracket of $[0,5]$, the second (after 2 iterations) iterative value of the root of $te^{-t} - 4 = 0$ is

   A. 0
   B. 1.25
   C. 2.5
   D. 3.75

4. The absolute relative approximate error at the end of an iteration in bisection method can be written in terms of the lower and upper guess, x_l and x_u, respectively as

   A. $\left|\frac{x_u}{x_u + x_\ell}\right|$
   B. $\left|\frac{x_\ell}{x_u + x_\ell}\right|$

C. $\left|\dfrac{x_u - x_\ell}{x_u + x_\ell}\right|$

D. $\left|\dfrac{x_u + x_\ell}{x_u - x_\ell}\right|$

5. The root of $x^3 = 4$ is found by using Newton-Raphson method. The successive iterative values of the root are given in the table below

Iteration Number	**Value of Root**
0	2.0000
1	1.6667
2	1.5911
3	1.5874
4	1.5874

At what iteration number would you trust at least two significant digits in your answer?

A. 1
B. 2
C. 3
D. 4

6. The ideal gas law is given by

$$pv = RT$$

where p is the pressure, v is the specific volume, R is the universal gas constant, and T is the absolute temperature. This equation is only accurate for a limited range of pressure and temperature. Vander Waals came up with an equation that was accurate for larger range of pressure and temperature given by

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT$$

where 'a' and 'b' are empirical constants dependent on a particular gas.
Given the value of R = 0.08, a = 3.592, b = 0.04267, p = 10 and T = 300 (assume all units are consistent), one is going to find the specific volume, v, for the above values. Without finding the solution from the Vander Waals equation, what would be a good initial guess for v?

A. 0
B. 1.2
C. 2.4
D. 3.6

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