MA162: Finite mathematics

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January 26, 2010

Schedule:

- HW A2 is due Monday, Feb 1st, 2010.
  Deadline: notify me by email of need for alternate exam
- HW A3 is due **Sunday**, Feb 7th, 2010.
- Exam 1 is Monday, Feb 8th, 5:00pm-7:00pm.
  Practice exam **now available**
- HW B1 is due Monday, Feb 22nd, 2010.

Today we will cover 2.1, systems of linear equations.

2.1: Systems of equations

- Very little in life is simple. It is rare you only have one thing due.
- In many situations, there are three limiting factors:
  - Time — You need people to do it
  - Money — Supplies don't come cheap
  - Space — You need somewhere to work
- Real decisions require you to balance several inputs, and maximize at least one output, **profit**

2.1: The word problem

- B.B. King LLC now employees part-time beaders to manufacture beaded bracelets
- You use an ingenious three step process: **thread** the beads, **crimp** the wire, **attach** the clasp
- You sell three types of bracelets: **A**urora, **B**abylon, and **C**amelot
- Your threader works 3 hours a week, your crimper 5 hours a week, and your attacher works 4 hours a week
- Time in minutes to complete each step for each type:

	Aurora	Babylon	Camelot	Available
Thread	2	1	1	180
Crimp	1	3	2	300
Attach	2	1	2	240

2.1: How do you keep them busy?

- You were smart enough to schedule:
  your Threader to work Mondays,
  your Crimper to work Tuesdays, and
  your Attacher to work Wednesdays
- But how many of each type should each person make?
- If different people make different amounts, then you have surplus partially made bracelets.
- Everybody needs to make the same amount of each, but it takes people different times to do each.
- How does one find the balance?

2.1: Make a bad guess?

- One option is to just guess. Some managers do this.
- "Why not just make all Babylons?"
- The Threader can make 180 Babylon bracelets each Monday.
- The Crimper can make 100 Babylon bracelets each Tuesday, leaving 80 uncrimped threads.
- The Attacher has time to attach 240 Babylon bracelets, but only got 100 bracelets from the Crimper, so 2 hours and 20 minutes wasted

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2.1: Use algebra

- Suppose you tell your employees to make A Aurora bracelets, B Babylon bracelets, and C Camelot bracelets
  Here A, B, and C are specific, but unknown to us, numbers we want to find
- The Threader spends $2A + B + C$ minutes threading, out of his 180 minutes.
- The Crimper spends $A + 3B + 2C$ minutes crimping, out of his 300 minutes.
- The Attacher spends $2A + B + 2C$ minutes attaching, out of his 240 minutes.

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2.1: Equations

- Now we just state that we want to use all the time:

$$\begin{array}{lrrrl} \textbf{Threader:} & 2A & + B & + C & = 180 \\ \textbf{Crimper:} & A & +3B & +2C & = 300 \\ \textbf{Attacher:} & 2A & + B & +2C & = 240 \end{array}$$

- Now we want to solve these equations,
  but perhaps this one is a hard place to start
- Suppose the Attacher offers to work 20 hours
  (so effectively he is no longer a contraint)
- Suppose there is a safety recall on the Camelot
  (twin axle bracelets were extra safe, until you added the sword)
- The new equations are simpler:

$$\begin{array}{lrrl} \textbf{Threader:} & 2A & + B & = 180 \\ \textbf{Crimper:} & A & +3B & = 300 \end{array}$$

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- We start solving:

$$\begin{array}{lrcl} \textbf{Threader:} & 2A & + B & = 180 \\ \textbf{Crimper:} & A & +3B & = 300 \end{array}$$

- We write $A = 300 - 3B$ using the second equation
- So A really is just $(300 - 3B)$
- so $2A + B$ really is just $2(300 - 3B) + B = 600 - 6B + B = 600 - 5B$
- so $180 = 2A + B = 600 - 5B$
- so $5B = 600 - 180 = 420$, so $B = \frac{420}{5} = 84$ Babylon bracelets
- so $A = 300 - 3B = 300 - 3 \cdot 84 = 48$ Aurora bracelets

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2.1: Checking our answer

- We claim that $B = 84$ and $A = 48$ use up all the minutes exactly
- We should probably check (before telling the entire company)
- The Threader needs $2 \cdot 48 = 96$ minutes to thread the Auroras and $1 \cdot 84 = 84$ minutes to thread the Babylons
  A total of $96 + 84 = 180$ minutes!
- The Crimper needs $1 \cdot 48 = 48$ minutes to crimp the Auroras and $3 \cdot 84 = 252$ minutes to crimp the Babylons
  A total of $48 + 252 = 300$ minutes!
- The Attacher needs $2 \cdot 48 = 96$ minutes to attach the Auroras and $1 \cdot 84 = 84$ minutes to attach the Babylons
  A total of $96 + 84 = 180$ minutes, much less than 20 hours
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Lab time: Activity 2.1a

- Form groups of 1-4 people and begin working on activity 2.1a
- You will be given a **short quiz** on the material at the end
- Collaboration is encouraged, but write down your own thoughts
- Write neatly enough for your own notes,
  but you will not hand in anything but the quiz
- You may also try to solve the full BBKing problem:

	Aurora	Babylon	Camelot	Available
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2.1: Degeneracy

- We've all heard "There's no such thing as a dumb question"
- However, there are definitely "unreasonable demands"
- Not all equations can be solved; **inconsistent**
- Sometimes equations are not enough to find the solution; **free variables**
- These "special" cases are called **degenerate**

2.1: Impossible Mission

- Your mission, should you choose to accept it:

- Please determine the number x such that $x - x = 4$.
  $x - x = 0$ not 4, there are **NO** solutions

- Please determine all numbers x such that $0 = 1$.
  Changing x is not going to make $0 = 1$, **NO** solutions

- Please determine all numbers x such that $x = x$.
  All x work, x **is free**

- Please determine all pairs of numbers (x, y) such that $x = 3$.
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2.1: Marketing the mission

- Suicide missions are rarely labelled as such
- Determine all solutions to the system of simultaneous equations: $3x = 9$ and $4x = 5$

  $x = 3$ from the first, but $4 \cdot 3 = 12$ not 5; **NO** solution
- Determine all pairs of numbers (x, y) such that $2x + 3y = 5$ and $4x + 6y = 2$

  $4x + 6y$ is twice as big as $2x + 3y$, but 2 is not twice as big as 5; **NO** solution
- Determine all pairs of numbers (x, y) such that $4x + 3y + 1 = 3x + 3y + 4$

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Lab time: Activity 2.1b

- Form groups of 1-4 people and begin working on activity 2.1b
- You will be given a **short quiz** on the material at the end
- Collaboration is encouraged, but write down your own thoughts
- Write neatly enough for your own notes,
  but you will not hand in anything but the quiz
- You may also try #13 in section 2.1 of the textbook
  (easy version of exam question)
  Find the values of k such that

$$2x - y = 3, 4x + ky = 4$$

is inconsistent. $k = ?$

Quiz: 2.1

- Solve the system of equations:

$$\begin{aligned} x \quad +0y \quad +2z &= 3 \\ y \quad -2z &= 4 \\ z &= 5 \end{aligned}$$

  Or written more compactly, $x + 2z = 3$, $y - 2z = 4$, $z = 5$.

- Solve the system of simultaneous equations:

$$\begin{aligned} x \quad +0y \quad +0z &= 3 \\ y \quad +0z &= 4 \\ z &= 5 \end{aligned}$$

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