

## **An Alternate Presentation Method for Final Examinations**

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### **Introduction**

Final examinations are a stressful time for everyone involved. In an effort to reduce the stress level (and have a little fun), over the last several years some of the faculty in the Biological Resources Engineering Department at the University of Maryland have given final examinations in the “Great Literature” format. The Great Literature series of final exams is based upon recognizable literary masterpieces. The styles and general contents of these examinations mimic those of the literature they represent. The courses in which this examination format has been used include a graduate course in Instrumentation Systems and undergraduate courses in Biological Systems Controls and in Biological Responses to Environmental Stimuli.

### **Examination Objectives**

While the content of the courses in which the Great Literature exams varied widely, the objectives for using the format were similar. These objectives were (1) to provide context form the calculations that the students were performing, (2) to require the students to demonstrate that they could isolate and manipulate critical information from a larger set of information, and (3) provide a humorous milieu in which to present final examination requirements.

A common problem in engineering learning is developing relationships between a theoretical presentation of a subject matter and practical engineering skills. In our experience, students benefit from developing these ties. By providing examinations in a “story” format, an examination’s problems were placed within a context. That is to say that students could relate the theoretical problem solution with the scenario in which the problem was presented.

Engineering students are often visual learners and problem solvers. These learners prefer and intellectually respond to problems that they can visualize. Story problems let them perform this visualization. In fact, some students responded to the examinations in kind, and submitted “great literature” answers. Another result of this set of examinations is that they evoked sympathy for the students taking the course. However, the examinations have been well received by the students during the examinations and we have received positive comments at the end of the semester.

Practicing engineers seldom make decisions in the absence of a context. By providing a context, decision-making skills could be developed. This form of examination was designed so that the information required for a problem’s solution was not neatly provided. In many of the examinations, students were required to extrapolate from the presented data or required to make educated assumptions. The students were also required to separate the essential information from

the superfluous information. The development of a student's capacity to sort and analyze data benefited from having a context in which they could make decisions. In most cases, the examinations were given as "take home exams." This gave the students the time required for this development.

Finally, the use of a humorous scenario reduced the students' test taking anxiety. It is hard to mix stress and laughter. The authors prefer to see their students laugh.

## The Examinations

Below we present several examples of the Great Literature Examinations.

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### **The Quest for the Holey Pail**

*(Biological Systems Controls)*

**T**hus, begins the tale of Syr Conan the Librarian and Dame Rosamund the Reluctant. It was a time of great adventure and heroism. It was the time of the quest for the "Holey Pail."

Sigismund, King of the Snails, knew that his Kingdom was in trouble. As time had passed, he had become more and more sluggish. Twisting one eyestalk, he looked back at his shell. It was almost gone. He had only one choice. He must obtain the Holy Pail from Caffeina, the Lady of the Puddle. Calling for his knights, he oozed over to the legendary "vaguely ellipsoid table."

Only a few hours later two of the greatest knights of the Realm appeared. Rosamund the Reluctant stood before him. Her shell had been polished till it glowed with a light of its own and she wore a tabard bearing her arms (Argent, a snail guardant contourny, gules). Beside her rested her long spear. Across from her sat Conan the Librarian, font of obscure knowledge. His arms (gyronny of sixteen, Or and sable, a gorge counterchanged) had been painted on his shell in vibrant colors, and his sword 22 calibre hung from his side. Both of them exuded confidence (or was that slime?). Sigismund looked grave has he told them of their quest.

They packed that evening and oozed out into the crisp air the following morning. After only a few feet they came upon the trail leading away from the castle. This was the road to the cave of the Wicked Witch, Wanda the Wombat. Wanda was the last of the great magical wombats. She had seen the grail.

Now it is not our task to talk of the many obstacles that had to be overcome to reach that cave. I will not tell you of the high stick they climbed, nor the asphalt of doom, nor their encounters in the drainage ditch. Those are stories for other times.

Reaching the door of the Wombat, Roz rapped it smartly with the butt of her spear and waited for an answer. They heard a rustling inside and then silence. Roz rapped again. After a short while, Wanda appeared. Snarling, she looked down at Roz and Conan.

"I challenge you to Mortal Wombat, a battle of wits!" She sneered. "If you can answer three of my questions, I will answer three of yours. My questions are:

1. Find  $X(t)$  for the equation:

$$X(s) = \frac{s+1}{s(s^2 + 2s + 2)}$$

2. Draw a signal flow diagram describing this equation in the observer canonical form.
3. If the characteristic equation below can be used to describe your King, is he stable? (use the Routh criterion)"

$$s^4 + 3s^3 + s^2 + 3s + 6$$

To these questions, they replied, "The answers to these questions are obvious. Even ENBE471 students could answer them. We will have them do so and reply by December 16, 1998 at 5 p.m."

In the face of such obvious brilliance, her Wickedness could only yield. She told them what they must find.

"You must acquire four magical objects," she said. "The first of these is my cauldron. It makes 24 cups. Guard it well. The second is the cord of power. The great sorcerer Sloopy the Sloth holds this item. The third is the heater of control. This is hidden in the great salt mine. Only after you have these will the Lady of the Puddle answer your call and give you the Holy Pail."

With this our intrepid heroes went to seek the Sloth. They found him hanging by his toes from the highest tree in the forest. Roz and Conan called out to him and requested permission to approach his greatness, but he heard them not. Sloths generally don't pay much attention to snails. So, they cried out again, and he heard them not. Finally, in his anger, Conan swung the mighty sword 22calibre and struck the tree making a great noise.

To this, the great sorcerer responded "The cord of power is here. But I can only give it to you if you truly understand the flows and efforts of power.

- 4) Give me these for thermal, chemical (diffusion), electrical, and rotational energies.

Then, I shall give you the cord."

After receiving the cord, the snails rested for the night. In the morning our two intrepid heroes awoke to find that their shells had completely disappeared. As their loss sank in, they realized that they must now face the horrors of the salt mine as (dare they whisper it) ....slugs. Slowly they oozed towards the mines, wondering what their fate might be. The loss of water from a slug may be modeled as a first order lag process with a time constant of 20 hours. Furthermore, the slugs begin to loose water the minute that they crawl into the mine (treat it as an applied step change).

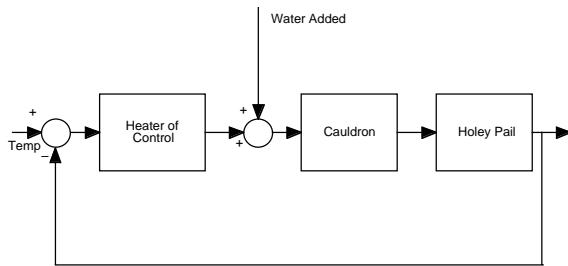
- 5) Would they survive the salt mine, if it takes them an 97.5 minutes to get to the bottom of the mine and 100.23 minute for them to return with the heater of control? Assume that they can loose 20% of their water and still survive. Justify your answer.

In this story, however, they do survive. Slowly and weakly they crawled from the mine.

“Water, water” they cried as they oozed towards the Great Puddle. After what seemed like days, but was only about fifteen minutes, they reached the Great Puddle. Drinking deeply, they rested. While they rested, the waters in front of them began to glow faintly. The glow continued to brighten. Slowly, dressed in glistening samite, Caffeina rose from the depths of the puddle.

With tears in her eyes, she addressed them, saying “here is the Holey Pail. It is filled with ground beans of great power. Assemble this with the cauldron, the heater of control, and cord of power. When this is done, place 24 cups of water from this puddle in the cauldron. Drink the resulting potion and you shall cease to be sluggish.

If the magical apparatus can be diagrammed as



Assume that the heater of control is a PID controller of the form

$$K(1+0.5s+0.1s^{-1})$$

The Holey Pail can be modeled as having the transfer function:

$$\frac{1}{s+1}$$

The Cauldron can be modeled as having the transfer function

$$\frac{1}{24s+1}$$

- 6) Use Mason's gain formula to determine the overall transfer function for the system assuming a step change in temperature.
- 7) What is the open loop gain for the system?

- 8) What are its poles and zeros?
  - 9) Generate a root locus plot for this system. Check yourself using MATLAB.
  - 10) It is always stable?
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**The Shaming of the True**  
**Dramatis Personae**  
*(Instrumentation Systems)*

A LORD  
B LORD  
O LORD } Persons in the Induction

BAPTISMAL,	a rich gentleman of Paddock
PINOCCHIO,	a wooden-headed gentlemen of Pizza
ENGINEIRIO,	a stalwart technologio, played by the ENBE 601 student
KATHERINIO,	feeder of the shrews
MARK ANTONIO,	character from another play who changes his first name to “San” and adopts a surname moniker of TEX.
SAGGITARIO,	the hunter
SERVANTS,	quite a few

SCENE - Paddock, a large country estate in central Italio.

INDUCTION  
Inside an alehouse  
A LORD, B LORD, AND O LORD sit before the hearth.

A LORD.  
‘Tis a wager the rogues may bet; Before he tire  
And gently to his bed doth go.  
That within a week or so,  
Bethink of a means to salve old Sire’s woe.

B LORD.  
And a more weighty burden cannot be so,  
For the wealthy inhabitant of that great estate

Has seen fit to be the unwitting host to guests  
of great number,  
Although the shrews acknowledge not his hospitality.

O LORD.

What can be done to tame his troubles?  
Solv'd in a blink as time goes.  
Yet, my Lord, as the ale is  
    clear'd before the glass is fill'd  
I'll take your wager that the scholar,  
    looking on with consternation,  
Has the means to employ a correct response,  
To this final examination.

A LORD.

Should the Heavens be aligned so regular  
that nary an error wilt be made?  
Nay, your wager is on. My shekels  
support the pessimist foretelling  
inappropriate rejoinder.

## ACT I.

Paddock. The Villa  
Enter BAPTISMAL and PINOCHHIO walking together

BAPTISMAL.

Pinocchio, since for the great desire I had  
To see fair Paddock, from fruitful Lombardy,  
The pleasant garden of great Italy,  
And, by my father's love and leave,  
Have stay'd these years within these villa walls,  
Remov'd from the merchants of Venice in another play.  
Yet my offspring Katherino has habits  
Undesirable for my quiet years.

PINOCHHIO .

Say it again, Sam.

BAPTISMAL.

Nay. Who can remember? But Katherino  
Consumes crackers in her bed.  
Her crumbs she drops beneath the sheets  
In slobbery, disarray,  
Leaving them for servant hands to clean,  
With no thot to the attraction she poses for villa vermin.

PINOCHHIO.

Can you not arrest her untidy habits, my friend?

BAPTISMAL.

Wait. You have not heard all.  
When by her hand she has made one bed uncomfortable,  
She moves to another, and yet another,  
Until all one hundred one rooms of the villa  
Have succumbed.  
Villa vermin are everywhere!

PINOCCHIO.

Uncouth habits indeed.  
She is so headstrong,  
That even young Petruchio cannot crack her.  
My sympathy for your plight.

## ACT II

Paddock. The Villa.

BAPTISMAL sits in his chair.  
SAGGITARIO knocks on the door.

BAPTISMAL.

Who is there?

SAGGITARIO (from outside the door).

Comand.

BAPTISMAL.

Comand, who?

SAGGITARIO.

Comand open the door.

BAPTISMAL.

I am glad to see you, Saggitario.  
Here to rid the villa of vermin.  
Ye'll have no trouble finding your prey.  
They are omnipresent I fear.

SAGGITARIO.

Cas'd the villa, I did.  
'Twill be a difficult hunt.  
For the vermin scute hither and yon,  
Moving from pile to pile and room to room  
Full of cracker crumbs and comfy sheets.

Before I ply my trade,  
And rid this villa of vermin,  
We must know if they are German.  
I know what I'll do;  
I'll call my buddy Engineirio.

### ACT III

Paddock. One room in the villa.  
SAGGITARIO and ENGINEIRIO are talking.

SAGGITARIO.

And this I propose to you,  
To monitor these villa vermin  
Sense the presence of each tiny mouse,  
And where it is within the house.  
Keep track of movement this way and that  
As they try to avoid the cat.

ENGINEIRIO.

How do you wish me to begin?  
It seems like a job t'me.

SAGGITARIO.

Sense mouse movement as cheaply as you can,  
In all one hundred and one rooms.  
Monitor in one location in the far wing,  
With special alarms for animal activity in the pantry or library.  
I must know whereabouts of the scum,  
Before I can rid them from this place.

ENGINEIRIO.

How large are they?  
Can they scute thru the walls?  
To see or not to see?  
Shall I nuc'em where they stand?

SAGGITARIO.

All kinds are here and all sizes too.  
They are in the walls and on the floor.  
'Tis not necessary to see'em.  
Nay, no nuc, leave the fun for me.

ENGINEIRIO and SAGGITARIO.

[This dialog is ad libitum in the classroom setting.]

ENGINEIRIO.

I think I can.  
I think I can.

SAGGITARIO.

Sir, we will be victorious, in this villa.  
[Exeunt].

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## The Red Hombre

(*Instrumentation Systems*)

Captain First Rank Marko Ramirez of the Paraguayan Navy was dressed for the special occasion to occur later that day. Five layers of louse-infested castaway uniform parts enclosed his slightly-bloated body. A filthy harbor tug sputtered its engines as it pushed ever so gently against the Red Hombre. It was the first mission for the first submarine in Paraguayan history. On its decks was a diverse collection of ragtag paramilitary adventurers who would soon discover that the decks of submarines do not stay dry for long.

“Engines ahead slow, Karlos,” he ordered. Karlos fumbled. Ramirez frowned. Karlos was not quite sure he knew where the engine control was located. Ramirez frowned on, afraid that Karlos would ask the question of him. With a frown on his face, Ramirez looked formidable. Karlos never asked.

The submarine slid from her contact with the filthy harbor tug and began slowly plying the waters of filthy harbor. The Red Hombre was a sight to behold. Made from scraps bought at yard sales around the world and smuggled into Paraguay, the submarine was at once majestic and cobbled.

The sub was the same inside. Where instrument panels would have been found in other ships, large areas of emptiness presented themselves. Karlos did not know what to make of it. Ramirez knew that nothing had been made of it.

“Get me some assistants,” said Ramirez. “This sub needs instruments. Without them we’re lost.” Karlos obeyed quickly. He contacted the ENAG 601 class, knowing that help could be gotten there cheaply.

“Never mind that you have a final examination coming up,” he intoned. “We need your help with some instrumentation issues. What we need are the answers to some problems that I know you can answer. Without them, we can’t hope to escape from filthy harbor. With them, we can move to new places and you can escape from ENAG 601. Neither you nor we can lose. Here is the list:”

1. Propose a means to measure the volume flow rate of a liquid flowing through a pipe using transit time ultrasonic flow measurements. Diagram the system completely, using only

components that you studied in this course. Fully describe the operation of each element and interfacing considerations between components. The system should terminate in a digital display of flow rate.

2. Describe the three means to transmit separate data values: separating values in time, space, and frequency. What types of hardware are required for each? Compare their merits. Show where each is more advantageous than the others to use.
  3. Discuss impedance issues. What care needs to be taken that impedances of two connected components are not mismatched? Give examples of nonelectrical impedances that are important in your work.
  4. If you were to purchase a digital data acquisition system, what are some of the important details that you should consider before buying?
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### The Raving

*(Instrumentation Systems)*

Once within my research meeting, while my thoughts were weak  
and fleeting,  
Over many a quaint and familiar host of forgotten lore -  
While I nodded, nearly napping, suddenly there came a tapping,  
As from my advisor rapping, rapping at my vision's door -  
“Tis some revenant,” I sputtered, “tapping at my vision's door -  
Only this and nothing more.”

Ah, distinctly I remember it was in the bleak December;  
And each musing’s dying demur wrought its part into my snore.  
Eagerly I wished the ending; - vainly I had tried mind bending  
From my psyche pulling, rending - rending of my thoughts galore -  
To that rare and radiant moment when this meeting be no more -  
Endless here for evermore.

Presently the noise grew stronger: hesitating then no longer  
“Sir,” said I, “I am pained, truly your forgiveness I implore;  
But you caught me lightly napping, and so gently you came rapping,  
And so faintly you came tapping, tapping to dissolve my bore,  
That I scarce was sure I heard you - now my eyes are wide once  
more;  
No need there is to shout and roar.”

Returning to the world around, speaking no longer any sound;  
Pensive, and receptive to instructions given twice before.

He towered before me glaring, moving not and stiffly staring,  
Uttered words no longer sparing, shaking me unto my core, -  
“Your assignment measures knowledge that you’ve taken into  
your core -

It’s that simple, and no more.”

“Out in Utah there’s a lake, its elevation you need to take;  
Fluctuating with sporadic rainfall events that came before -  
Digital data sent through space from such remote a place  
Removed, distant from the base; location of our laboratory door  
Power consumption must be small, far from our laboratory door; -  
Save that power evermore!

“Transmit data every fortnight, when request it, as you might;  
From past diurnal events; use computer, I implore,  
Show how to do this thing; block diagram, specs, and everything;  
Written solution you need to bring, bring to my office door  
In seven days at noon without excuse bring to my office door -  
Or it’s up a creek without an oar.”

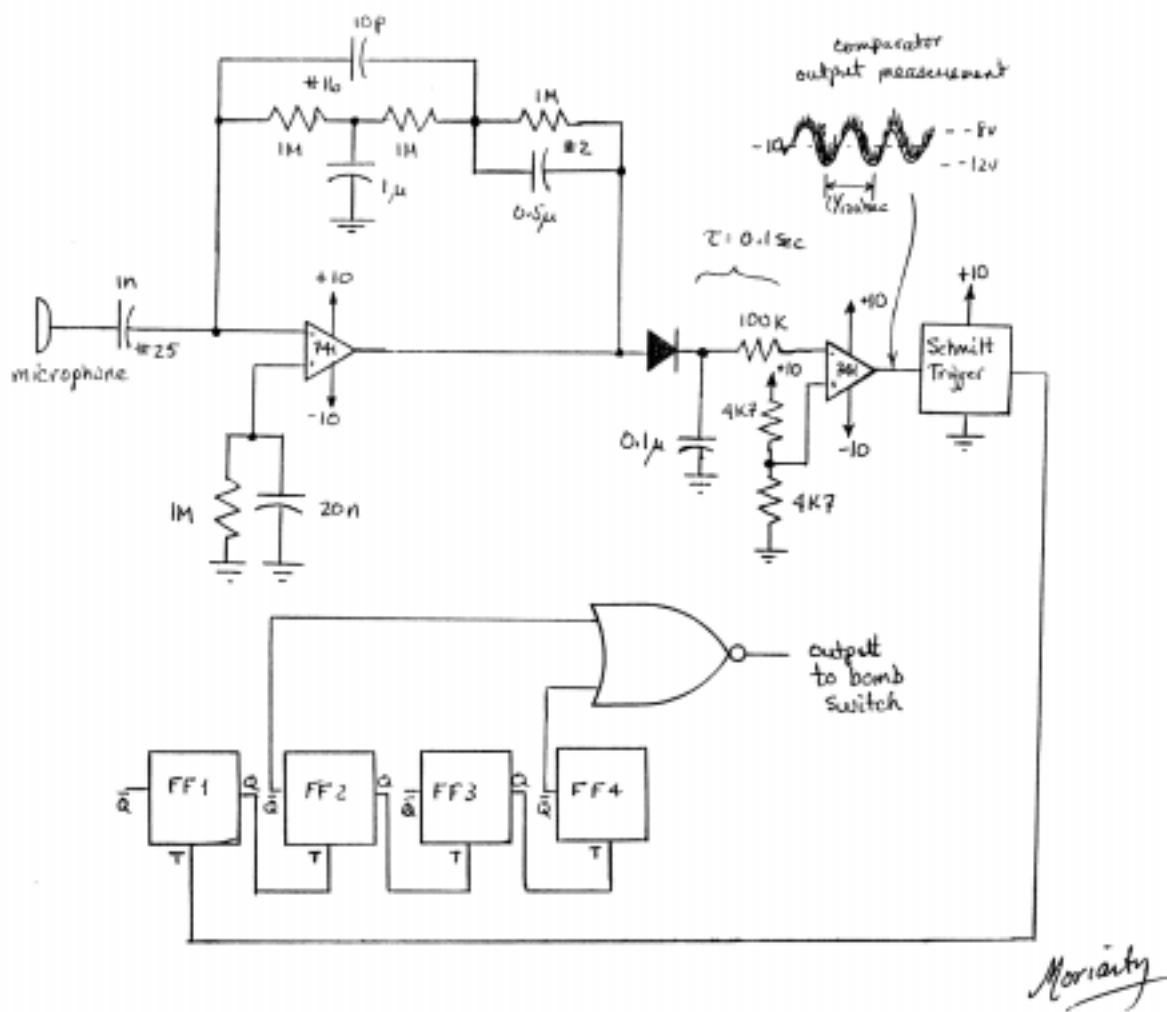
As I sat engaged in guessing, but no syllable expressing  
To the prof whose fiery words now burned into my very core,  
This and more I sat divining, with my head no more reclining  
Fully aware of my new assignment to be brought to his office door.  
How I loathed that unkempt office with the hard wood office door  
The sign attached says: Nevermore

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### The Final Problem

*(Instrumentation Systems)*

“It’s elementary, my dear Watson.” Ever since the students in ENAG 601 came to Sherlock Holmes with the package they had received from Professor Moriarty, Holmes and Dr. Watson had studied in detail the obviously homemade instrument. What diabolical devilment could Moriarty possibly be up to? What relationship was there between the nefarious nabob and the nervous neophytes who waited in the nippy night?



"It is lucky for us that Professor Moriarty is less of an instrumentation intellect than Professor Johnson, or we'd all be sorry," said Holmes. "This is obviously part of an explosive device gone awry. The first section is supposed to be a bandpass filter with a transfer function of

$$\frac{100\text{ s}}{\frac{s^2}{435,200} + \frac{0.02\text{ s}}{659} + 1}$$

The output of the filter is then supposed to be rectified by the diode and low-pass filtered with the resistor and capacitor. The output of this filter is checked by the comparator to see if it exceeds a  $7\text{ V}$  threshold voltage. If it does, then the Schmidt trigger produces a pulse, which is counted by the digital counter. The combination of digital gates assures that when the counter reaches 12, a switch is turned on.

"How diabolical of Moriarty. He planned to use the device to trigger an explosion on the twelfth peal of Big Ben. But his own cleverness concealed his childish understanding of analog and digital circuitry."

“From the measurements I made I determined that there are many errors that the peripatetic professor made when he conceived the device. I’ll bet even the most unsophisticated graduate student could better the professor.”

“Are you quite sure of your conclusion, Holmes?” challenged Watson.

“Quite sure,” Holmes replied, “why I’ll wager that the graduate student reading this could correct every blunder that Moriarty committed. There are fallacies in the bandpass filter, in the comparator, in the counter, in the digital decoding, and there is even a noise problem that requires reckoning.”

“Well, if that graduate student can solve these mysteries, I should think that she or he deserves an outstanding grade on this examination,” replied Watson.

“Yes, you surmise correctly,” said Holmes.

“Then we shall see,” said Watson.

“Yes, we shall see,” said Holmes.

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## ROOSTERS OF THE PURPLE SAGE

A final exam in three parts

*(Biological Responses to Environmental Stimuli)*

Virginia had always dreamed of running away from home to join the cavalry. She pictured herself riding tall in the saddle of a gleaming black quarter-chicken, fighting off the wild gerbils. She’d planned to return home to the Habitrail covered in medals. A hamster among hamsters. Her dreams were not like reality at all. It was a cold, wet morning on the prairie. The sun wasn’t shining. The birds weren’t singing and her riding chicken, Thor, smelled of damp feathers.

Still, she was riding one of only a thousand of the rare breed. Riding chickens tended to live forever (compared to the life span of a hamster, that is) and they were essential to keeping the clan alive. One chicken could support one hamster. That was the rule. If the clan wanted to grow they were going to have to find another herd of chickens...and soon. Virginia reached into her pocket, rubbed her lucky rubber ducky and scanned the horizon.

Startled, she thought she saw a flash of feathers in the distance. Was that a chicken in the distance? Bringing Thor to a trot, Virginia Hamster headed off. As she drew closer, she was astonished by her luck. Not only were there chickens, they were lead by a rare Rhode Island Red riding rooster. Quickly she brought Thor to a full gallop and set off in pursuit.

Suddenly, off in the distance, Virginia saw something that made her blood run cold with fear; a raiding party of the dreaded albino gerbils. The herd of chickens was the bait and she had fallen into the trap. To her left, she saw an oak tree that had blown over in the storm last night and made a break for it.

“Not very big,” she thought. “Maybe if I let Thor go for help...” Virginia dismounted, grabbed her Nerf pistols, and slapped Thor on the tail to send him home. Now all she could do was wait. She could see the gerbils, two to a chicken (gerbils could get by with only half the number of riding chickens), steadily trotting in her direction.

All she could remember was her grandfather’s advice: “Don’t fire until you see the pinks of their eyes!”

She saw the gerbils reach behind their backs, pull out their Nerf bows, and take aim. They still weren’t close enough. The waiting continued.

Virginia took careful aim. Every shot had to count. Squeezing her trigger, Virginia took aim at the front gerbil, fired, and watched the gerbil fall from his saddle to the ground. In response, a hail of Nerf arrows headed her way. Virginia fired another shot, and another. She lost track of time. The world focussed down to reloading, firing, reloading and firing. Looking down she realized that she only had one more clip of darts. When that clip was gone, they had her. Then, the world went black.

Virginia saw a bright light in the distance. It was calling her. Suddenly, everything hurt and someone was shaking her shoulder. She opened her eyes and looked up. It was the most wonderful sight she had ever seen, a handsome golden Syrian. Apparently she had been left for dead by the gerbils. The search party had followed Thor, found her and brought her back to the Habittrail.

*You may use a numerical analysis program (such as MATLAB or Mathematica) to solve the problems, if you wish.*

- 1) Assuming that the doctor is unable to remove the suction cup from Virginia and that the suction cup is made from medical grade silicone rubber, what is the tissue’s response to the implant.
- 2) Compare the mechanical structure of the prairies grasses and the tree. Describe how each copes with the high winds.
- 3) Given the data

$$\begin{aligned} \text{Initial # of hamsters} &= 100 \\ \text{Initial # of gerbils} &= 160 \\ r_m \text{ for hamsters} &= .78 \\ r_m \text{ for gerbils} &= .62 \end{aligned}$$

what would the population growth curves look like for:

- a) the hamsters and the gerbils, assuming an unlimited number of riding chickens.
- b) the hamsters, assuming that the number of riding chickens is limited as described above and there are no gerbils present.
- c) the gerbils, assuming that the number of riding chickens is limited as described above and that there are no hamsters present.
- d) the gerbils and the hamsters assuming that they are only competing for the available chickens and not fighting with each other.
- e) write (but do not solve) the series of differential equations describing the growth of the populations, if there were a clan of field mice which compete with the gerbils and hamsters for the chickens. One chicken can support three field mice.
- f) assuming that the chickens are k-selected and the gerbils are r-selected, sketch the number of survivors as a function of age for the two populations.

Extra credit: Write a paragraph ending the story.

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#### **PAUL SCHREUDERS**

Paul Schreuders is an Assistant Professor of Biological Resources Engineering at the University of Maryland. He teaches Biological Systems Controls and Biological Responses to Environmental Stimuli to seniors and is part of a team developing a completely web based course. His research interests include cryopreservation and the structure and function of bacterial biofilms.

#### **ARTHUR T. JOHNSON**

Art Johnson is a Professor of Biological Resources Engineering at the University of Maryland. Best known for his design work on the life support systems for Noah's Ark, he continues to tell bad jokes and to teach Biological Process Engineering to juniors and Bioinstrumentation to graduate students. His research interests include breathing and watching students run on a treadmill.