Expert Test Questions for Neophyte Learners

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Opportunities and New Directions
Wednesday April 28, 2010
University of Waterloo, Waterloo, Ontario, Canada

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Interactive Session

- Goals:
  - 1) experience being a neophyte learner,
  - 2) guidelines for instructors on testing neophyte learners.
- Delineate core concepts and threshold concepts, mini-quiz
- Acting as neophyte learners, participants take on different expert questions.
- What we learned from students.
- Guidelines for instructors
- Conclusions

Core Concept vs Threshold Concept

CORE	THRESHOLD (Meyer and Land 2003)
"Building block" ●Does not change world view ●Linear progression	"Gateway" ●Transformative ●Probably irreversible ●Integrative ●Possibly often bounded ●Potentially (possibly inherently) troublesome

Participants' Questions:

Does it depend on who's learning?

Does it depend on prior knowledge?

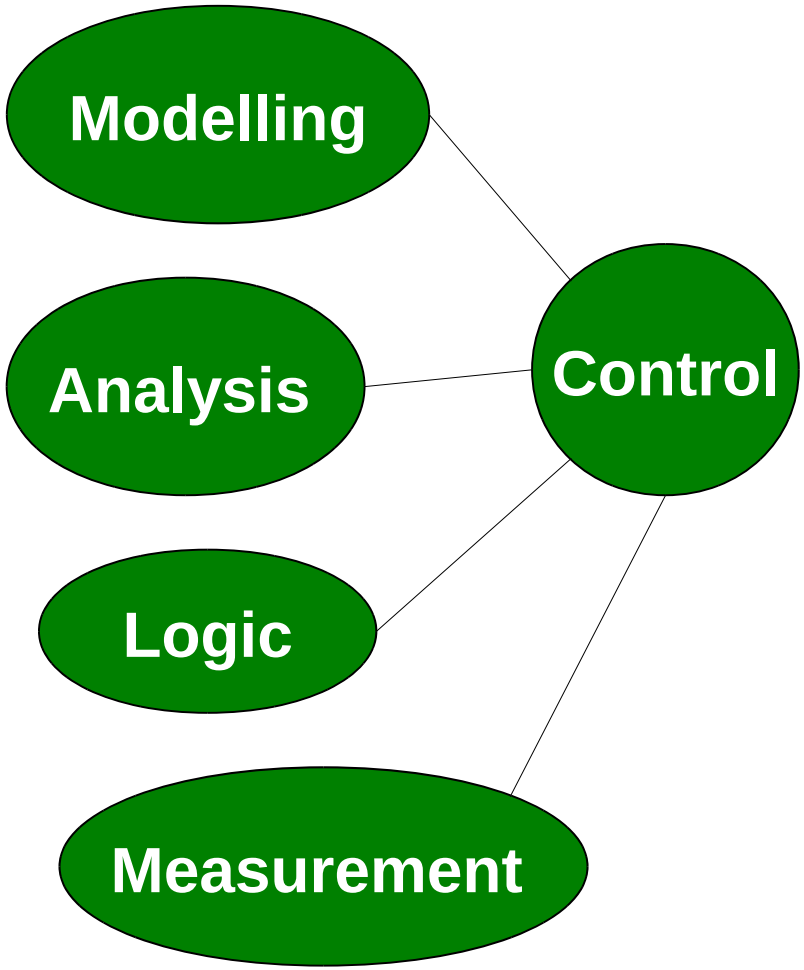
Can a threshold concept be considered "core" when it is needed to learn something that builds on top of the threshold concept?

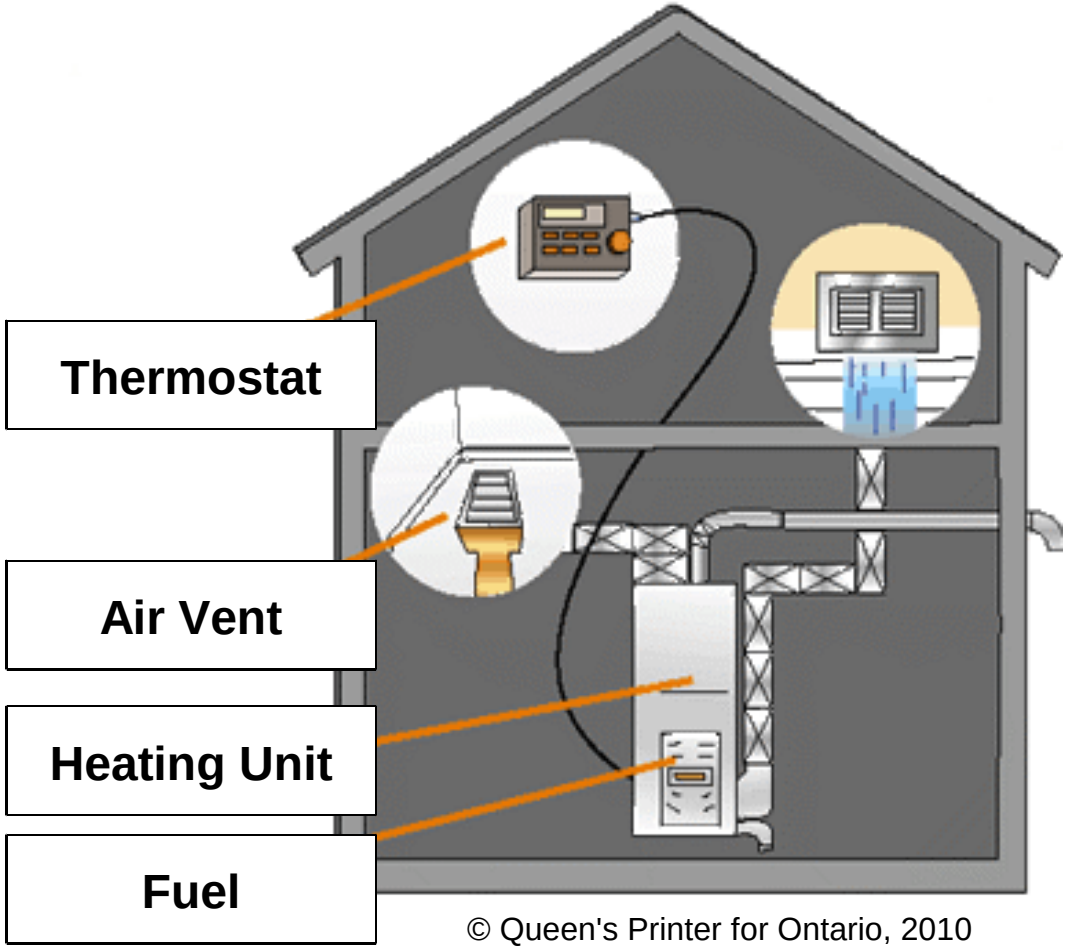
Quiz: Core or Threshold?

- Gravity
- Opportunity Cost
- Complex Number
- Limit
- Heat transfer
- Signification
- Others?

Post Test:
Quick assessment of understanding after teaching a new concept.

Control Systems: Integration of Concepts





Testing Conceptual Understanding

- Generally, it cannot be tested explicitly.
- Some indicators (Kilpatrick et al., 2001)
  - able to represent a situation in different ways;
  - able to avoid critical errors;
  - able to reconstruct forgotten methods;
  - able to make sense of new situations, and to generate new knowledge to solve unfamiliar problems.

Control System Design

A design competition for the next generation electric car is underway and you have the task of designing the cruise control system. To start you have the following system:

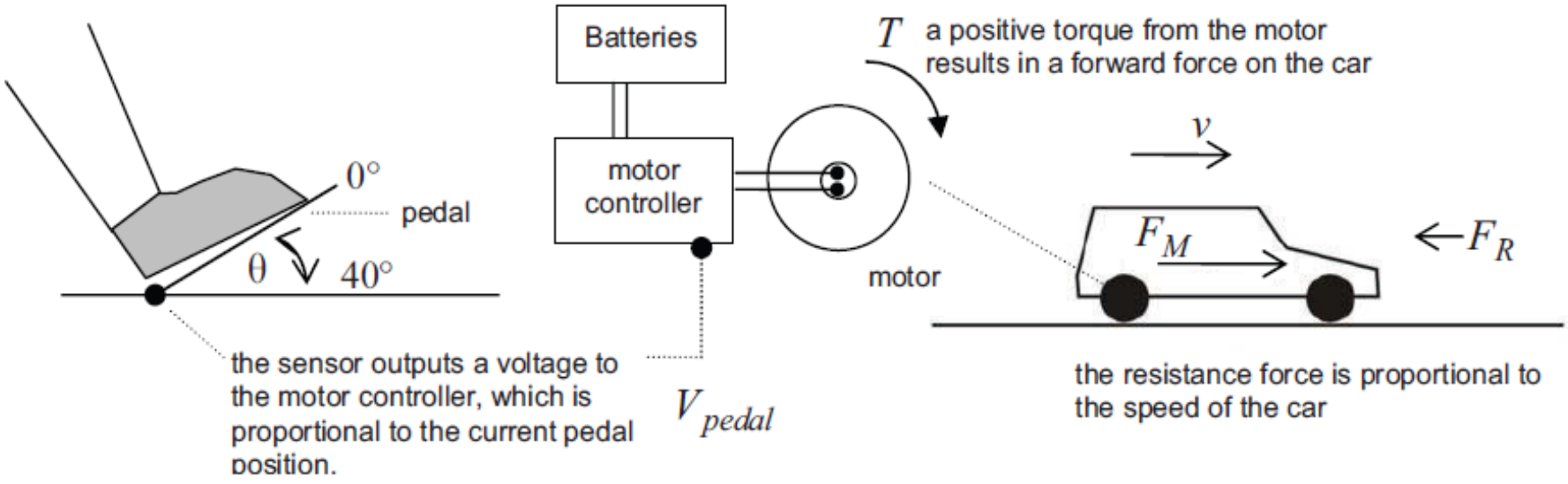


Figure 2. Accelerator pedal, electric motor and free-body diagram of the car

Figure 3. Input/output system and Laplace transform of differential equation

[*Additional description is provided to explain diagrams and variables.*]

Design Questions

If the car is stationary on a level road and the pedal is 'floored' (i.e., $\theta = 40°$), the car will accelerate to 75km/hr in 4 seconds and eventually reach a maximum speed of 120 km/hr.

What are the values of the system gain, k, and time constant, τ ,in Figure 3?
Select one answer from each column.

i. System Gain	ii. Time Constant
a) k = 1/3 [km/hr/°]	a) $\tau \approx 4$ seconds
b) k = 3 [km/hr/°]	b) $\tau \approx 1/4$ Hz
c) k =120 [km/hr/°]	c) $\tau \approx 1$ second
d) k =1.875 [km/hr/°]	d) $\tau \approx 0.4$ Hz

Design Questions

The driver wishes to cruise at 60 km/hr, and so holds the pedal at $\theta = 20°$. The car now goes up a long hill and the car speed slows to 50 km/hr. What is causing this effect on the system?

a) forces on the car have changed
b) gain of the system, k, has changed
c) time constant, τ ,of the system has changed
d) an increase in resistance force,
e) I have no idea.

To compensate for the slope of the road, the driver presses the pedal further down (increasing θ). How much further should the pedal angle be increased to boost the speed from 50 km/hr to 60 km/hr while going up the hill?

a) 0.002° b) 3.3° c) 4.0° d) 10° e) I have no idea.

What we learned from students

- Multiple Choice: students will want to guess - *give students a way out (or as suggested during session, a scale to rate their confidence.)*
- Consistently correct answers boost signal that students actually understand the fundamental concepts – *distinguish between understanding and getting lucky by asking different types of questions testing the same concept.*

Analysis Question

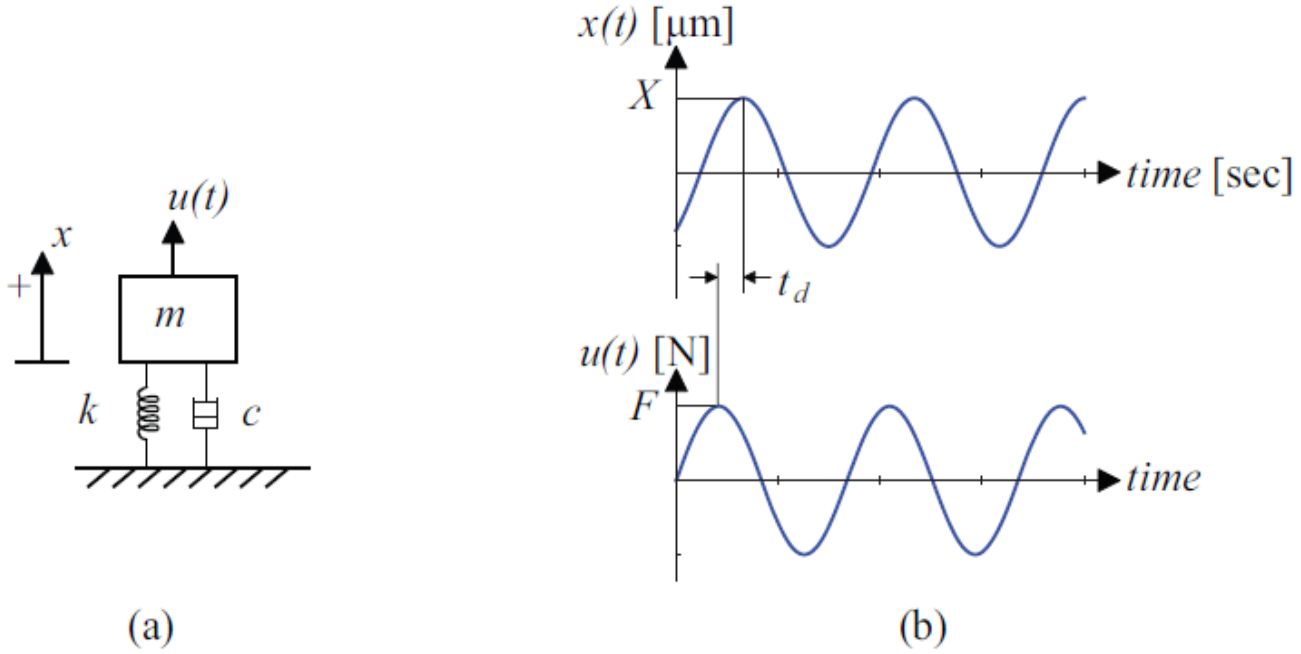


Figure 7. (a) Mass-spring-damper system, and (b) force input $u(t)$ and displacement output $x(t)$

A mass-spring-damper system (see Figure 7 (a)), when excited with a sinusoidal force input $u(t)$ produces a displacement output $x(t)$ which has the same frequency f[Hz], but a different amplitude, as shown in Figure 7(b). The amplitude ratio is defined as $A = X/F$. A time delay t_d between the applied force and the actual displacement is due to a lag, or phase shift, in the system response. The relationship between the phase shift ϕ[rad] and the time delay is $t_d = \phi/2\pi f$[sec].

Analysis Question

This system was tested by applying sinusoidal forces at different frequencies and recording the corresponding amplitude ratio (A) and phase shift (ϕ) for each frequency in a graph. (Note that k=1). This type of graphical representation is also known as a “Frequency Response plot” or a “Bode plot”. The results are plotted in Figure 8.

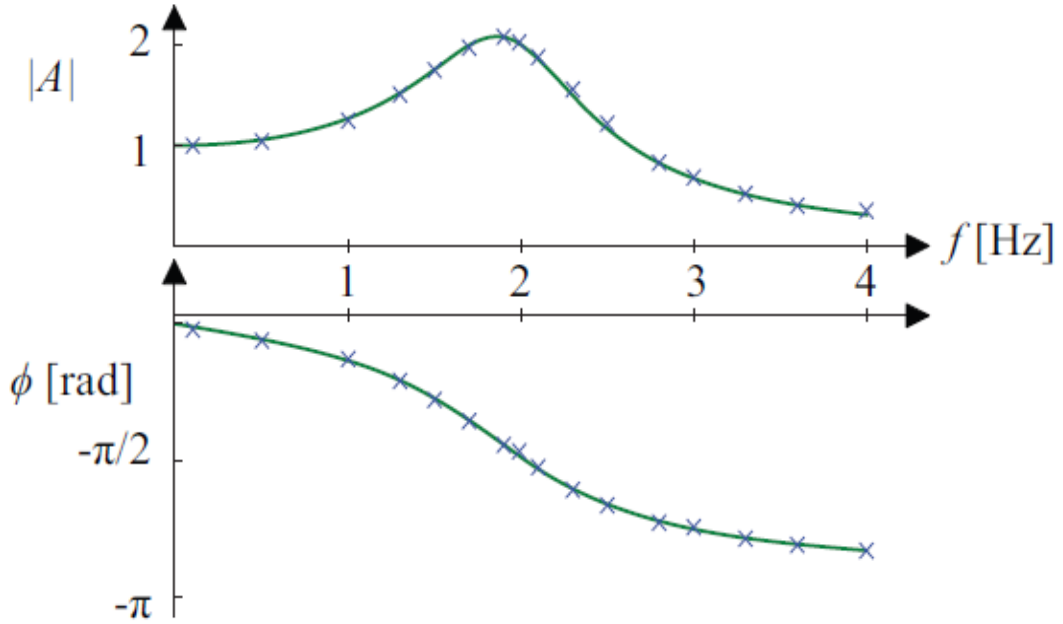
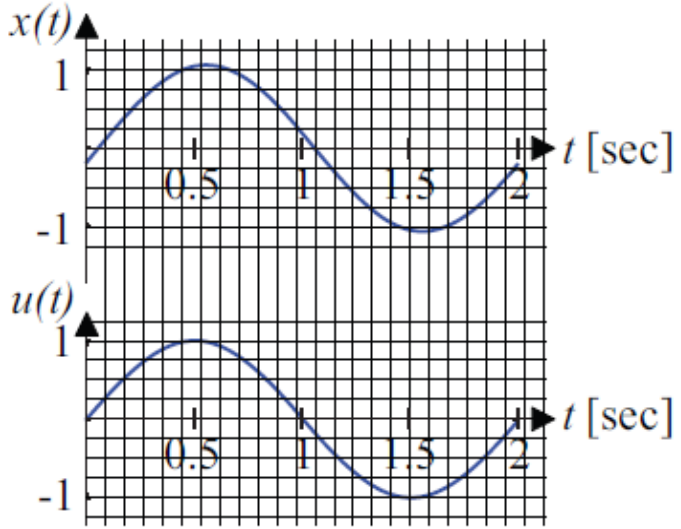


Figure 8. Bode plot

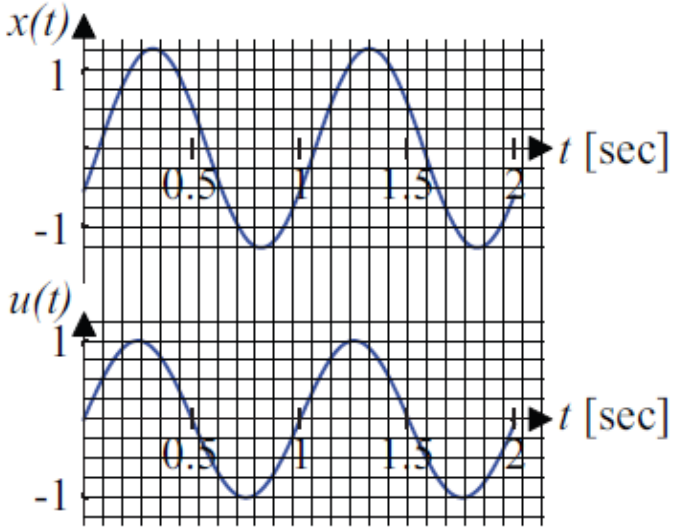
Analysis Question

Based on the measurement results in Figure 8 , which of the following responses for force and displacement cannot belong to this system?

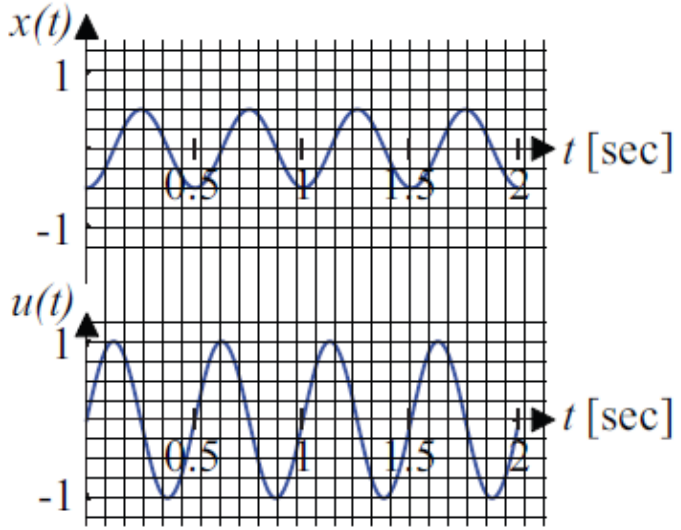
a)



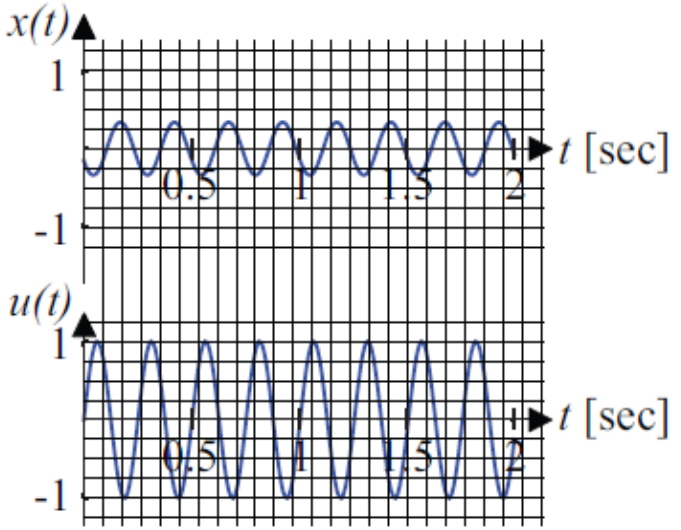
b)



c)



d)



What we learned from students

- Students felt overwhelmed - amount of information
- Needed to work on their ability to work with visual input data

Open-Ended Question

In your own words, concisely describe or illustrate the process of filling up a bucket with water from a hose as quickly as possible to the very top of the bucket but without overflowing. Assume that you can control the flow of water from the hose with a valve, and that the flow rate through the valve is proportional to the rotation of the valve handle.

What we learned from students

- Given the opportunity, students will express what they know. But...
- Only some students will reflect on what they have learned and apply it.
- Many students did not show significant change in their answers (pre vs post) and did not apply concepts taught in this course to the question.
- Do students need to be prompted to relate their answers to what they learned in the course?

Reactions to Types of Questions

- Comfort ?
  - Overwhelming, information overload
  - Reflecting on one's knowledge
- Motivation level ?
  - failure
  - success
- Conceptual level ?
  - Think to Understand
  - Understanding to Communication

General Guidelines

- Test Design:
  - Use familiar/everyday context
  - Provide permission to “fail”
  - Cross check – test same concept in different ways
- Test Development:
  - Collaboration
  - Iteration

General Guidelines

- Pre/Post Testing:
  - Coach instructors and students on the role of the test
  - Expect uncomfortable feeling in pre-stage – it's OK to “fail”
  - Focus on transition, growth or change indicators
  - Expect more confidence in post-stage, but beware of persistent misconceptions

General Guidelines

- Extract feedback from test on how students handle different information types
  - Numerical, Graphical, Plain language
  - Consistent answers demonstrate conceptual understanding
  - Focus on areas of inconsistency to improve course design and operation

Conclusions

- Neophyte learners often are overwhelmed – allow them to make mistakes and learn.
- Focus on concepts in a familiar context for them; use plain language.
- Use different information type questions to test conceptual understanding – consistency shows better understanding.

Questions?

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This research project was funded by a University of Waterloo Learning Initiatives Fund Grant, 2008-2010.