NAME:_____ **PART A**

MECH 372 Space Systems Design and Engineering II
Exam 3 - Fall 2014

Part A - Closed Book - 32 points

1. (18) True or False (1 pt each):

T F a) The three defining components of a computer or microcontroller are the processor, the keyboard, and the monitor.

T F b) The Fetch-Execute model of software execution consists of "fetching" the next instruction from memory, and then "executing" that instruction by performing the specified operation. "Execution" is typically done by performing a computation or by moving data bits from one location to another.

T F c) A central challenge for flight processing is the need to do multiple tasks concurrently. A common strategy of dealing with conflicting, "simultaneous" software tasks is to re-engineer one of these tasks so that it is implemented in hardware.

T F d) When expressed in standard binary notation, the number 114 may be written as 01110010.

T F e) Software engineering is very similar to mechanical engineering given that the disciplines are hundreds of years old, they both exploit basic laws of physics to inform their analytic techniques, etc.

T F f) The equation $x=r*\cos\theta$ is an example of a kinematic relationship.

T F g) Consider a vector written in Frame A. If I want to take the time derivative of this vector, I must do this with respect to Frame A.

T F h) One must be careful when applying Newton's Law to the analysis of mechanisms on spinning spacecraft because a device's acceleration expressed in spacecraft coordinates won't be proportional to the actual forces applied to the device.

T F i) If a body is in equilibrium, then it cannot be moving.

T F j) A regular (not inverted) pendulum is considered to be positively stable.

T F k) One of the two primary justifications for using closed looped feedback control (vs. an open loop strategy) is to counteract the effect of external disturbances, which may be unpredictable.

T F l) The actuator of a spacecraft mechanism is commanded using a proportional control strategy and applies a torque of 10Nm when the error is 1° of angular position. If the error grows to 2°, then the actuator will provide a torque of 5Nm.

T F m) For brushed DC motors, output torque is proportional to the voltage applied to the motor.

T F n) Triangulation is a navigation technique that uses three measured distances in order to determine location.

T F o) For a wireless communication link, cutting the transmission data rate in half will cut the quality of the link (signal to noise ratio) in half.

T F p) For a wireless communication link, doubling the distance between transmitter and receiver will cut the quality of the link (signal to noise ratio) in half.

T F q) For a wireless communication link, doubling the transmit power will double the quality of the link.

T F r) For an observing satellite, increasing the aperture size will decrease the field of view.

2. (2) Briefly state (no more than 2 sentences) a few of the primary differences between embedded computing compared to general computing one might do using a PC-based workstation.

3. (2) Briefly state (no more than 1 sentence) a few of the main tasks that a primary flight computer would typically perform. Note that I am NOT looking for special functions that a payload computer might do, but rather a few of the standard tasks that must be done on nearly every spacecraft.

4. (1) Why might it be normal to expect that decade-old computing technology might be selected for flight on a specific spacecraft?

5. (3) A central challenge for flight processing is the need to do multiple tasks concurrently. Consider a situation in which one of the members of your design team, a flight processing engineer, says that they are trying to implement a specific function in software but that it must execute simultaneously with another function that is already implemented. They are trying to decide on whether to implement the new function through an interrupt process or by using a parallel processor. What do these two options mean, and what are the pros/cons of each?

6. (2) Consider an observing mission in which the satellite is supposed to have very good resolution (a small number for resolution) and which is supposed to be "agile" (which means that the satellite can be very quickly turned from one object to another). The payload engineer has decided that he wants to quadruple the aperture of the payload (from 0.5 m diameter to 2 m diameter) in order to significantly improve resolution. What are the probable concerns expressed by:

a) The structural engineer:

b) The attitude control engineer:

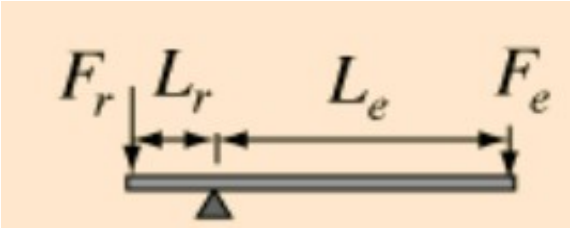
7. (2) On the axis provided, draw the time response of a first order system with an initial condition of 10 units/sec and which decays to a final value of 0 units/sec with a time constant of 10 sec. Your sketch should be to scale, and both axes should indicate numeric values.

8. (2) To balance the lever (e.g., to place the lever into equilibrium with no angular velocity), determine the force F_e that should be applied to the system at the location provided. In addition, determine the Ideal Mechanical Advantage (IMA) of this simple machine.

Given: $L_r = 2$ meters
$L_e = 5$ meters
$F_r = 10$ N

$F_e =$ _____

IMA = _____



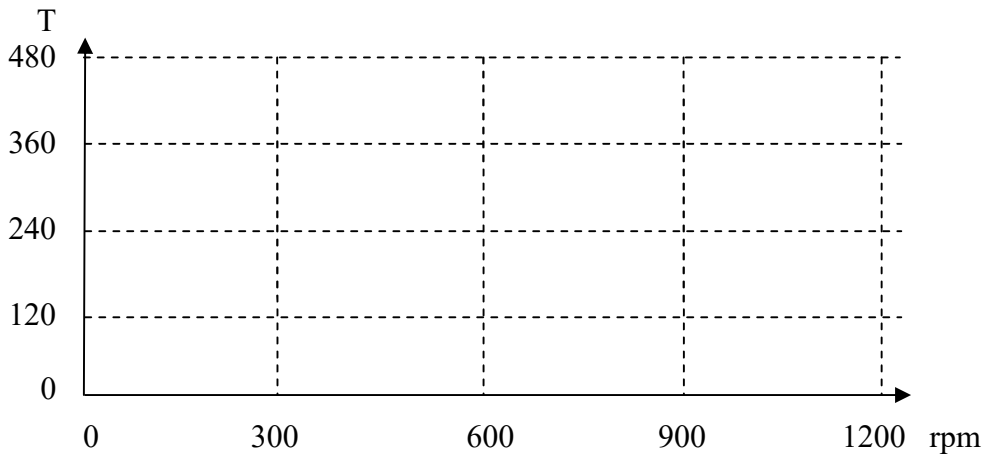
NAME:_____ **PART B**

MECH 372 Space Systems Design and Engineering II
Exam 3 – Fall 2014

Part B - Open Book – 18 points

BOX YOUR SOLUTIONS

9. (6) A dc motor is rated at 12V with a stall torque of 120 oz-inches and a max speed of 1200 rpm. It is operated with a gearbox that has an 3:1 mechanical advantage. For a particular task, the motor voltage is dropped to 6V. Show the equivalent Torque-Speed curve for motor in this operating configuration. While in this configuration, if the motor is moving at a speed of 100 rpm, how much torque is it exerting? Plot this operating point.



10. (2) Perform a simple 2-D planar trilateration analysis by considering two signal sources that each broadcast a signal that moves at 1 unit per second. Source A is at a location of (10,0) in the XY plane, and Source B is at the location (0,15) in the XY plane. Your receiver states that you are approximately 14.14 sec away from Source A and approximately 5 sec away from Source B. Provide at least 1 of your possible locations in the Cartesian plane?

11. (3) Imagine having an observing payload optimized for viewing objects that are 100° C. The payload is on a satellite orbiting at an altitude of 1,000 km, and it has an aperture of 2 meters.

a. What is the peak wavelength of emission given off by the objects of interest?

b. What is the instrument's resolution at this wavelength for objects directly below the satellite?

c. If the payload is commanded to look at object's on Earth that are not directly below, with the effective resolution increase or decrease, and why?

12. (3) This problem is unlike the problems you've been given on the homework. It is an attempt to make you apply your understanding of a specific topic rather than simply reproduce problems that you have seen before. Do not panic. Think it through, and you'll be fine. With this problem, I am interested in assessing your understanding of the geometric issues relating to trilateration, specifically, the issue that some choices of landmarks are better than others. Here is your scenario. You are somewhere in the XY plane. You have 4 landmarks to choose from in order to perform your trilateration analysis. As I hope you recall, you can use two landmarks in order to find 2 specific candidates for your location. The use of a third landmark will typically narrow those 2 down to a single possibility. However, poor geometrical arrangement of the landmarks and your location may prevent this from happening. For this problem, consider the 4 landmarks you are given. I want you to select 3 of these that allow you to determine a single location for your position. As you do this, you most likely will run into options where 3 specific landmarks won't work. Again – provide a list of the 3 landmarks you would choose to use in order to determine your position in the XY plane without any ambiguity.

The table shows the location of each landmark as well as the distance that you are from each.

Landmark	Location	Distance .
A	(1,5)	5*sqrt(2) units
B	(1,0)	5 units
C	(1,-5)	5*sqrt(2) units
D	(8.5,0)	2.5 units

The 3 landmarks you choose are _____ , _____ , and _____ .

13. (4) Solar array drives rotate external solar array panels with respect to the main body of a satellite. These devices tend to be open loop mechanisms that spin at a constant rate (for GEO satellites) with the objective of rotating approximately 360 degrees per orbit. Because they are run open loop on a daily basis, they may not perform perfectly, and it is typical to go through a realignment procedure periodically in order to correct any built up error. For these reasons, designers and operators are often interested in knowing the accuracy and repeatability of these space mechanisms.

Drive	**Trial 1**	**Trial 2**	**Trail 3**	**Trail 4**	**Trail 5**	**Average**
Drive A	360.32°	360.51°	360.48°	360.39°	360.54°	**360.45°**
Drive B	360.12°	359.98°	359.96°	360.02°	360.03°	**360.02°**
Drive C	360.11°	359.89°	359.82°	360.24°	359.88°	**359.99°**
Drive D	359.89°	359.82°	359.90°	359.86°	359.80°	**359.85°**

Consider the 4 designs listed in the table. For each design, 5 experimental trials were run during which the angular rotation was measured over a 24 hour period. Given this data:

Which two have the best accuracy? _____ and _____

Which two have the best repeatability? _____ and _____