GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

**Ph.D. Qualifiers Exam - Fall Quarter 1996**

AUTOMATION IN MANUFACTURING

EXAM AREA

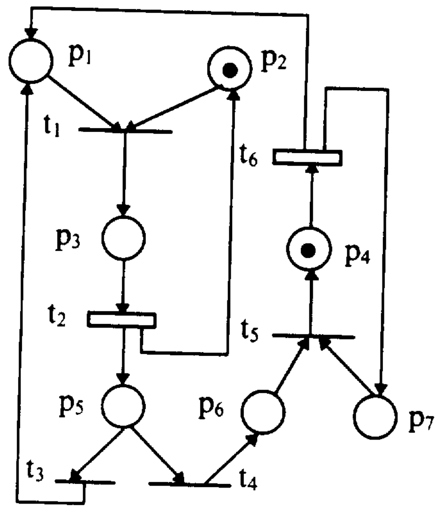
Assigned Number **(DO NOT SIGN YOUR NAME)**

**-- Please sign your name on the back of this page --**

1. Inventory and quality in manufacturing.

The management of the manufacturing enterprise includes concerns that are sometimes labeled "inventory control" and "quality control." Discuss each of these concerns and the sense in which they are control problems. In modern approaches to these (one or more should be briefly described) concerns, how do the two interact. How does manufacturing automation improve or complicate these modern approaches, if at all. In your discussion, be sure to address each of these issues explicitly. Your discussion should center around the issues raised, although some related issues may need to be discuss. You will be graded on conciseness, thoughtfulness, and the extent to which you can relate current thinking by the experts.

2. The Petri-net model of a closed central server comprised of an AGV and a single machine is given below. The Petri net transitions $t_1$ and $t_5$ are immediate, transitions $t_2$ and $t_6$ are exponential with firing rates $\mu_1$ and $\mu_2$, and transitions $t_3$ and $t_4$ are random switches with probabilities p and 1-p, respectively.




**a)** Explain what the places and transitions stand for and that how many parts can be in the system at any given time?

**b)** Find the reachablility graph and the resulting reduced embedded Markov chain (REMC) starting from the initial marking shown.

3. A technician has designed a force control system for a robotic gripper using a piezoelectric transducer and a HC11 micro-controller. The piezoelectric transducer (attached on one of the fingers) produces a voltage related to the strain to which it is exposed. The range of the piezoelectric transducer is ±2.5 volts and is scaled to 0 - 5 volts because this is the input range of the 8-bit A/D converter on the HC11. The HC11 has a software-programmable real-time clock implemented using an Interrupt Service Routine (ISR). The IRS generates an interrupt every 8*N microseconds and the number of interrupts, TC, is stored in 16-bit number. The value of N is programmable and has a default value equal to 1250.

In order to determine the structural stiffness of the finger, he "plucked" the free-end of the beam and registered the output of the A/D converter using the following program (pseudo code):

> *Initialize the IRS*
> *Set the interrupt counter to zero, (i.e. TC=0)*
> *FOR J=1 TO 800*
>     *Read ADC and TC*
>     ***Print the data (ADC, TC) to the host computer through a serial port of 9600 baud***
> *NEXT J*
> *End*

His results are shown in Figure 1(a) as a function of TC. He then removed the print statement (in bold) and repeated the experiment. With some tricks, he managed to plot some of his data obtained in his second experiment in Figure 1(b).

Recall that the vibration amplitude decay as $\exp(-\xi\omega_n\tau_d)$ where $\xi$, and $\omega_n$ are the damping ratio and natural frequency; and $\tau_d$ is the time between two adjacent peaks. You are asked to analyze the data, explain the problems of the experiment if there are any, and determine the resolution of the measurement. Discuss how would you improve the experiment in order to determine the damping ratio and natural frequency of therobotic finger.

Figure 1(a)

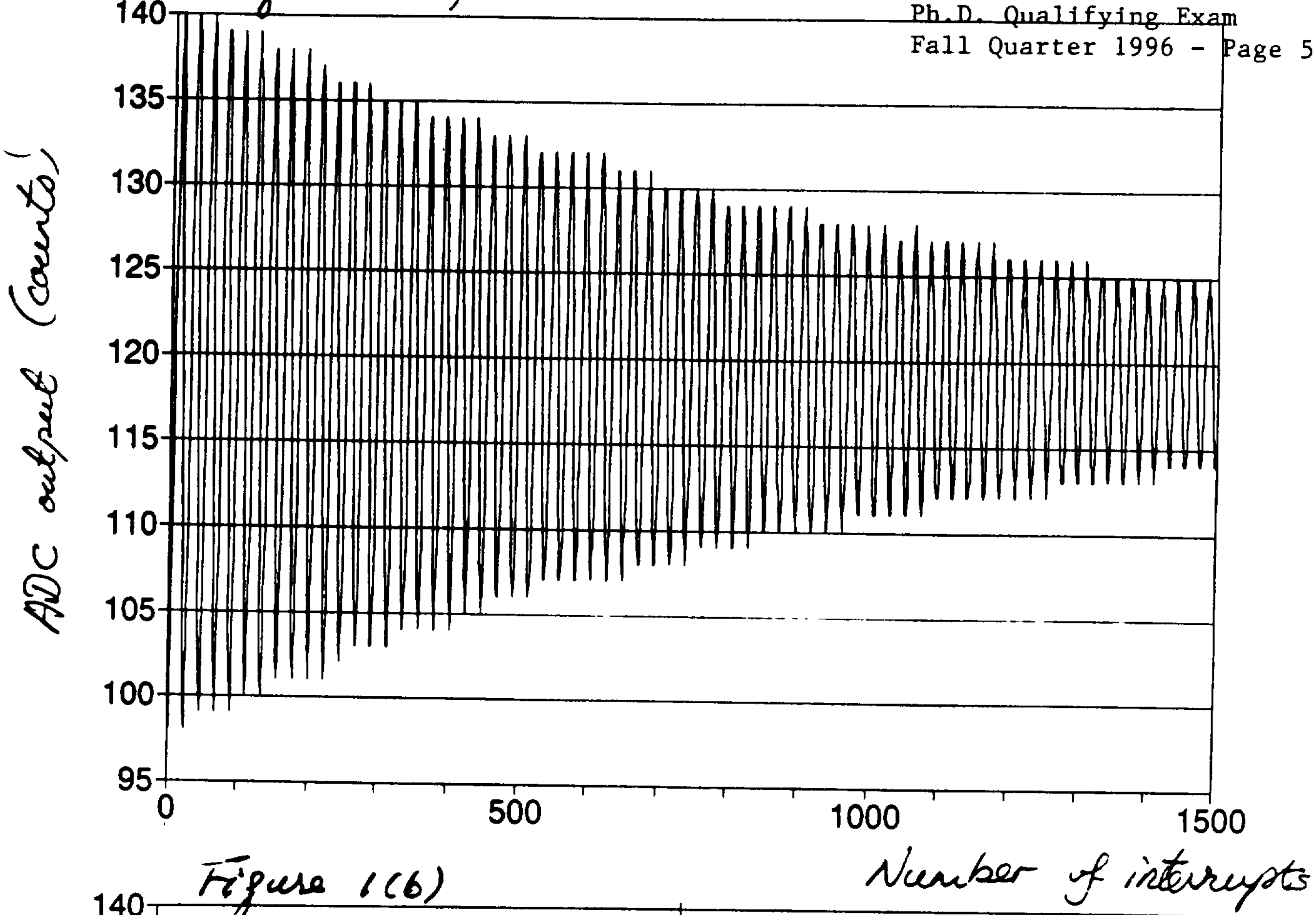



Figure 1(b)