# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

**FACULTY OF INDUSTRIAL TECHNOLOGY**

**DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING**

**INDUSTRIAL INSTRUMENTATION AND CONTROL II**

**TIE 3214**

**Main Examination Paper**

**April 2015**

This examination paper consists of 5 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Special Requirements: Graph paper, Semi-log paper, Laplace Transforms tables**

**Examiner's Name: Engineer L. Nyanga**

**INSTRUCTIONS**

1. Answer any five (5) questions.
2. Each question carries 20 marks.
3. Use of calculators is permissible.

## Question 1

(a) By means of a clearly labelled diagram, explain the priciple of operation of the Watt centrifugal speed governor. [5]

(b) Figure Q1 below shows a block diagram.Use block diagram reduction techniques to the equivalent transfer function $\frac{C(s)}{Y(s)}$. [15]

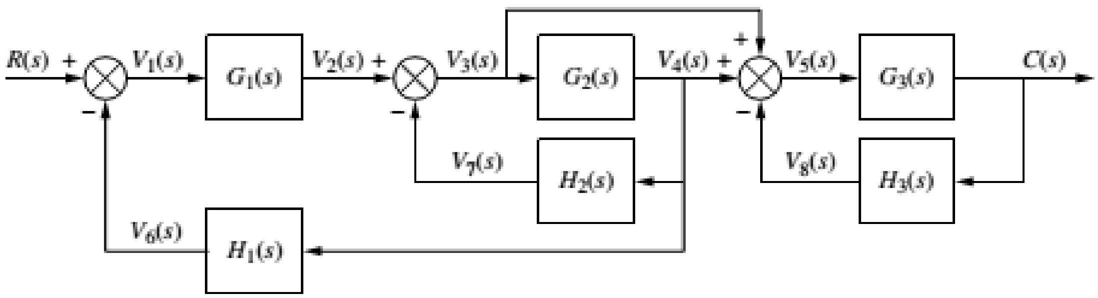


**Figure Q 1:Block diagram.**

## Question 2

(a) Given that the input to a system whose transfer function is G(s), is u(t) and the output of the system is y(t).

(i) Show this on a block diagram. [2]

(ii) Derive the error transfer function E(s) of the system in 2 (a) (i) above. [4]

(b) Find the steady-state errors for inputs of 5u(t), 5tu(t), and $5t^2u(t)$ to the system shown in Figure Q2. The function u(t) is the unit step. [9]

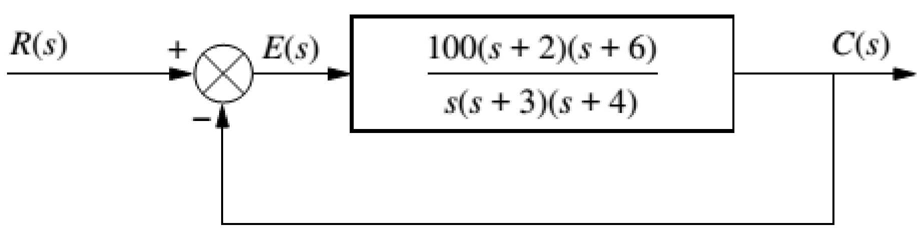


**Figure Q2: Feedback control system.**

(c) With the aid of a clearly labelled diagram explain a transient error and a steady state error.

[5]

### Question 3

Figure Q3 below shows the block diagram of a disk drive read control system.

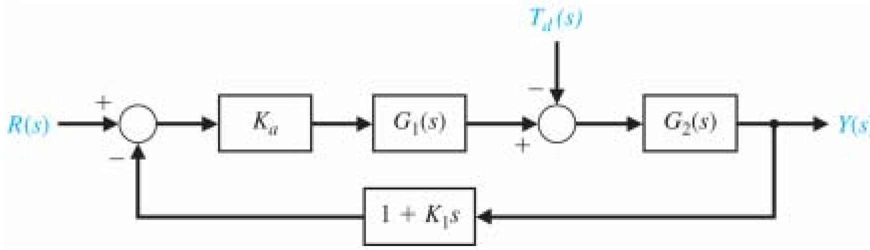


**Figure Q3: Block diagram of disk drive read control system.**

Given that $G_1(s) = \frac{5000}{s+1000}$ and $G_2(s) = \frac{1}{s(s+20)}$ .

Use the Routh-Hurwitz stability check criteria to find the values of $K_a$ and $K_1$ that would make the above system stable.

Hint: Ignore the effect of the damping signal $T_d(s)$. [20]

### Question 4

(a) Why do controllers need tuning? [4]

(b) Explain the Ziegler Nichols method of tuning PID controllers. [6]

(c) Find the value of the critical damping damping coeffiecient Cc in terms of K and M for the spring-mass-damper system shown in Figure Q4 below. [10]

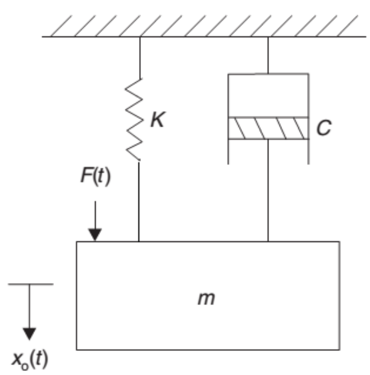


**Figure Q4: Spring-mass-damper system.**

**Question 5**

Figure Q5 shows a closed loop control system.

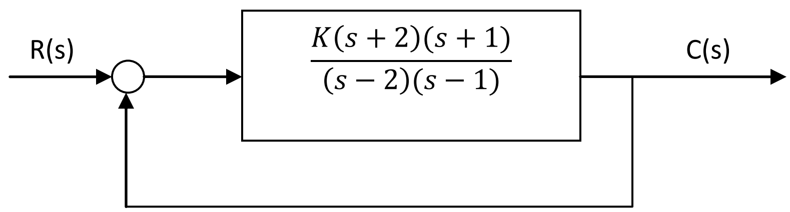


**Figure Q5: Closed loop control system.**

(a) Make an accurate plot of the root locus for the system in Figure Q5. [8]

(b) From the root locus plot you came up with in Question 5a find the following:

(i) The breakaway and break-in points. [2]

(ii) The range of K to keep the system stable. [3]

(iii) The value of K that yields a stable system with critically damped second-order poles. [3]

(iv) The value of K that yields a stable system with a pair of second-order poles that have a damping ratio of 0.707. [2]

(c) Write the Matlab code to find the root locus for the system. [2]

**Question 6**

Figure Q6 shows a block diagram of a control system.

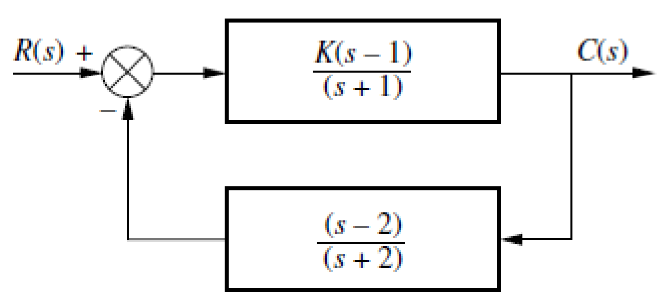


**Figure Q6: Control system block diagram.**

(a) Using the Nyquist criterion, find the range of K for stability for each of the systems. [10]

(b) Write a program in MATLAB that will do the following:-

- (i) Allow a value of gain, K, to be entered from the keyboard. [5]
- (ii) Display the Bode plots of a system for the entered value of K. [5]

**Question 7**

An antenna shown in Figure Q7 has an open loop transfer function.

$$\frac{6.63K}{s(s+1.71)(s+100)}$$

Use frequency response techniques to find the following:-

(a) The range of preamplifier gain, K, required for stability. [8]

(b) Percent overshoot if the preamplifier gain is set to 30. [3]

(c) The estimated settling time. [3]

(d) The estimated peak time. [3]

(e) The estimated rise time. [3]

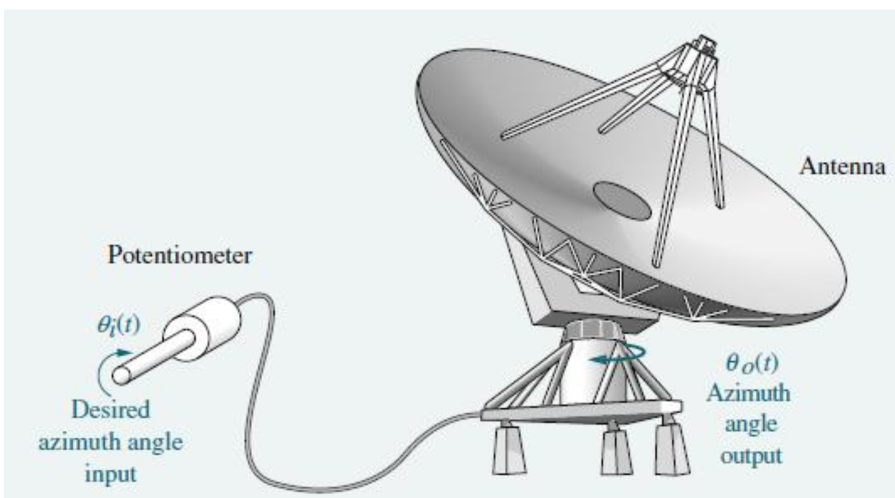


**Figure Q7: Antenna.**

**End of examination paper.**