PROGRAM	: NATIONAL DIPLOMA *ELECTRICAL ENGINEERING*
SUBJECT	: **CONTROL SYSTEMS III**
CODE	: **ASY331**
DATE	: SUMMER EXAMINATION 2015 16 NOVEMBER 2015
DURATION	: (SESSION 1) 08:30 - 11:30
WEIGHT	: 40:60
TOTAL MARKS	: 100

UNIVERSITY OF JOHANNESBURG

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NUMBER OF PAGES	: 5 PAGES AND 1 ANNEXURE	

INSTRUCTIONS

1. 100 MARKS = 100%. TOTAL MARKS AVAILABLE = 100
2. ATTEMPT ALL QUESTIONS.
3. ALL DIAGRAMS AND SKETCHES MUST BE DRAWN NEATLY AND IN PROPORTION.
4. ALL DIAGRAMS AND SKETCHES MUST BE LABELLED CLEARLY.
5. ALL WORK DONE IN PENCIL, EXCEPT DIAGRAMS AND SKETCHES, WILL BE CONSIDERED AS ROUGH WORK AND WILL NOT BE MARKED.
6. MARKS WILL BE DEDUCTED FOR WORK THAT IS POORLY PRESENTED.
7. QUESTIONS MAY BE ANSWERED IN ANY ORDER, BUT ALL PARTS OF A QUESTION, MUST BE KEPT TOGETHER.
8. ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED.

QUESTION 1

1.1 Determine the transfer function for the control system in figure 1, by using block reduction algebra. Do not use Mason's or Kirchoff's methods.

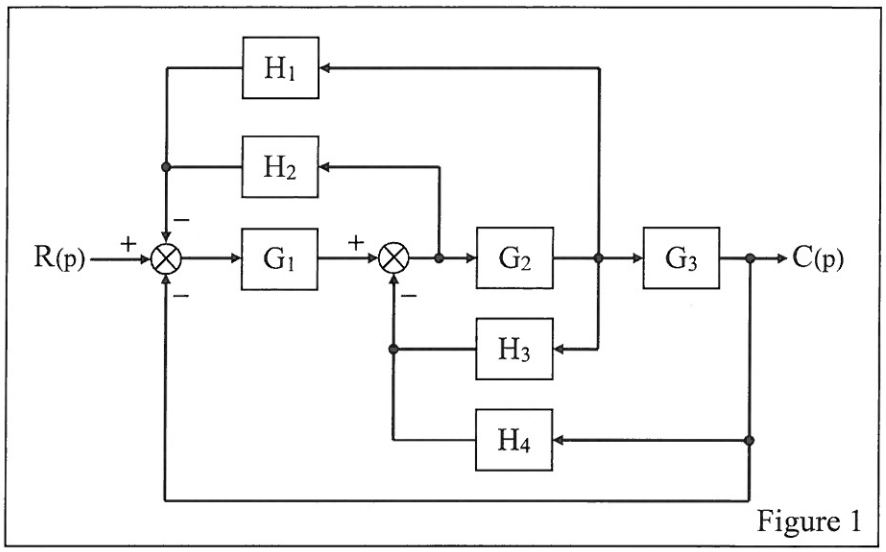

Figure 1

(10)

1.2 Determine the transfer function, $\frac{Vo(p)}{Vi(p)}$, of the electrical circuit shown in figure 2.

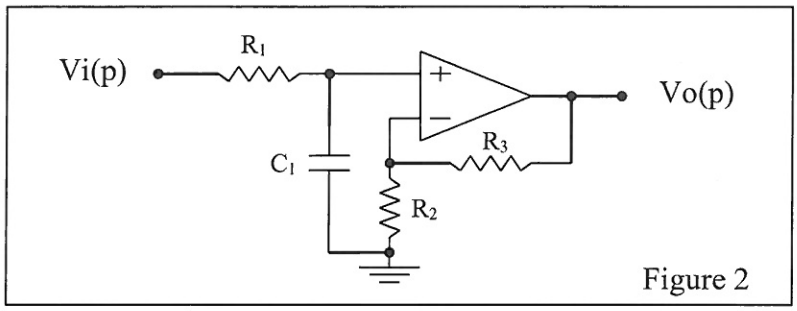

Figure 2

(5)

1.3 An electric motor is used to rotate a robot arm 90° from start to stop as shown in figure 3. The motor has a torque of 0.25 N·m and the robot arm length is equal to the pitch circle diameter of the 32 teeth gear. If the pitch circle circumference of the 32 teeth gear is 157 mm, determine:

1.3.1 How many rotor shaft rotations are required to rotate the robot arm through 90° up?

(5)

1.3.2 What lifting force in Newton's, will be exerted at the end of the robot arm?

(4)

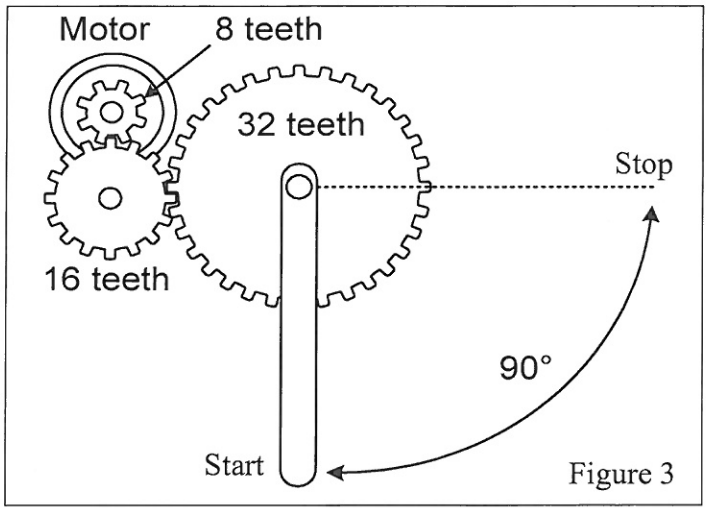

Figure 3

[24]

QUESTION 2

2.1 Sketch and label a block diagram of a closed-loop control system.

(5)

2.2 What is the advantage of implementing a closed-loop control system?

(3)

2.3 Describe the type of corrective restoring force produced by an integral controller and how it eliminates the steady-state error.

(2)

2.4 Explain how integral control can cause unstable oscillations due to a system nonlinear friction component.

(3)

2.5 Write the entire program flowchart that implements the following ideal PID equation algorithm on a digital controller.

$$CV_{PID} = K_P \left[E + K_I \sum (E \times \Delta t) + K_D \frac{\Delta E}{\Delta t} \right]$$

(12)

[25]

QUESTION 3

3.1 Explain how phase lag can cause a control system to become unstable at a given frequency.

(4)

3.2 In point form, list the Zieler and Nichols continuous-cycle PID controller tuning approach.

(8)

3.3 For each of the following type of second order system, illustrated by drawing small graphs of the root/pole locations on the p-plane, the damping ratio (δ) value and the time response graph for a unit step input disturbance.

3.3.1 Over-damped system
3.3.2 Critically damped system
3.3.3 Under-damped system
3.3.4 Un-damped system
3.3.5 Negative damped system

(7)

[19]

QUESTION 4

4.1 Give ten advantages of using compressed air for carrying out mechanical work.

(10)

4.2 A double-acting cylinder is to be used to transfer parts from a magazine. The cylinder is to extend fully when a push button is operated and then retract automatically. Full extension is confirmed by a roller lever valve. The cylinder is to continue extending even if the push button is released before full extension is reached. The speed of the cylinder is to be adjustable in both directions of motion. Sketch the pneumatic circuit diagram with the correct valve numbering system for the connection ports.

(7)

[17]

QUESTION 5

5.1 In a motor car repair workshop a lifting platform is operated by a three phase motor via a gearbox as illustrated in figure 4. The required operation is described as follows:

1) The lift is activated by an on/off switch, on the operator hand held unit. When the lift is switched on the run pilot-lamp must light up for indication.

2) While the up push-button is pressed the three phase motor forward contactor must activated to move the lifting platform up. When the top-limit switch is activated the lift must stop.

3) While the down push-button is pressed the three phase motor reverse contactor must activate to move the lifting platform down. When the bottom-limit switch is activated the lift must stop.

4) The lifting platform can be stopped at any intermediate position by releasing the up or down push-button. If both up and down push-buttons are pressed the three phase motor must not be allowed to start or has to stop immediately.

5) The three phase motor is protected by a thermal overload relay. When excessive torque is generated the overload relay disconnects the motor and the N/C auxiliary overload contact opens. The auxiliary overload is used as feedback to switch the run pilot-lamp off and switch the overload pilot-lamp on for indication while preventing any further motor contactor operation.

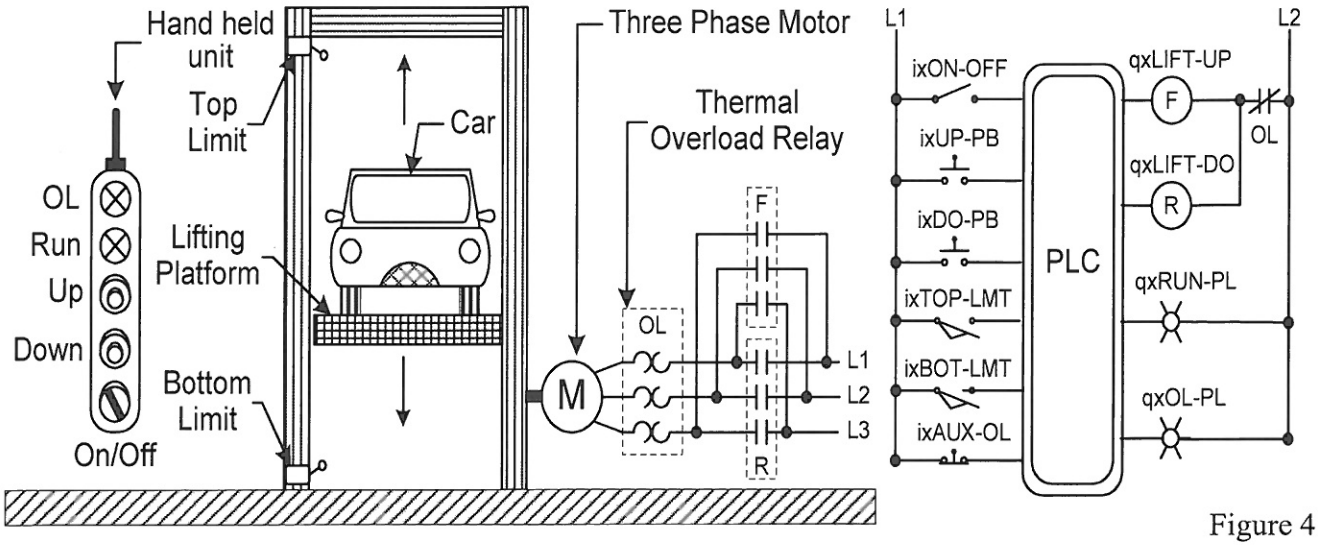

Figure 4

Design and sketch a PLC ladder program for the operator to control the lift via the hand held unit. Use the symbolic input and output connection names shown in the table below, in your PLC program. Only N/O or N/C contacts, output and internal relays may be used.

Symbolic Names	PLC I/O's	Description
ixON-OFF	%IX0.0	On/off switch input
ixUP-PB	%IX0.1	N/O push-button input
ixDO-PB	%IX0.2	N/O push-button input
ixTOP-LMT	%IX0.3	N/O push-button input
ixBOT-LMT	%IX0.4	N/O push-button input
ixAUX-OL	%IX0.5	N/C auxiliary overload contact input
qxLIFT-UP	%QX0.0	Forward contactor on moves lift up
qxLIFT-DO	%QX0.1	Reverse contactor on moves lift down
qxOL-PL	%QX0.2	On, overload pilot-lamp lights up
qxRUN-PL	%QX0.3	On, run pilot-lamp lights up

[15]

TOTAL [100]

Pneumatic Components and PLC function blocks