

MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The extent to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions.		
<i>Clear evidence of reading and good referencing though be careful to distinguish paraphrasing and quotes.</i>	10	8
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.		
<i>A good understanding shown. This is demonstrated in T4 with your approach to solving the CE without using 'Routh'.</i>	50	44
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence		
<i>In general your analysis is good. Though you have confused Poles - Zeros in T4. Poles in RHS ARE unstable.</i>	10	6
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.		
<i>Quite good overall. In T4 you missed an opportunity to gain extra marks due to the 'High Level' approach - more detail was required.</i>	25	13
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.		
<i>Quite good presentation. Try to use consistent diagram styles and be sure to provide figure numbers.</i>	5	4

Assignment Mark Overall (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		70	%
	Up to one-week late	Over one week late		



Course: HND In Electrical & Electronic Engineering

Course Code: BL1132FT1

Module: Dynamics, Control and Instrumentation

Module Code: M4X01405

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Assignment Title: Control Systems

Name of Lecture: Linton Cook

Assignment number: 1

Length/Format:

Date due: / /

Date Submitted: / /

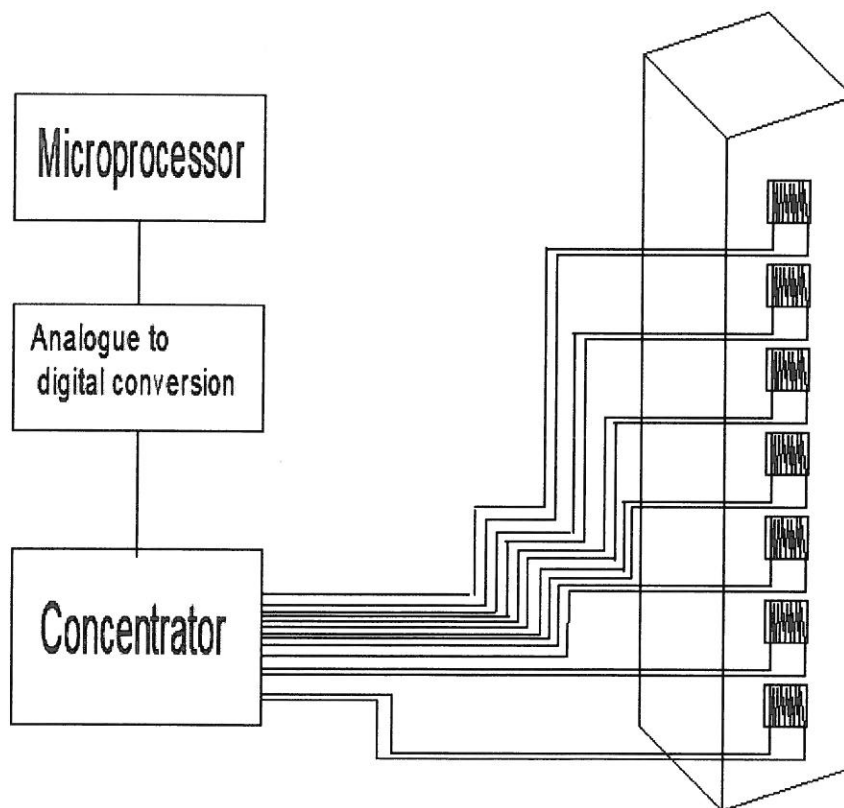
Grade:

Submitted via: email

Task 1

a) The system I would propose to determine the stress in the load bearing strut would be to use strain gauges bonded along the strut to determine the stress. A strain gauge is a sensor which resistance varies in portion to the strain the device is attached to. As the material experiences strain, either displacement or deformation, so does the strain gauge as it is made of very fine wire arranged in a grid pattern to that maximises the amount of wire that is subjected to strain. Once the strut is subjected to strain this is transferred to the strain gauge that sensors this as a linear change in its electrical resistance. If stretched, it increases resistance and if compressed it lowers its resistance. ✓
The amount or value of the effecting force can be derived from the change in resistance measurement of the strain gauge, as a strain value.

The system design proposal to measure the stress on the load bearing strut would consist of numerous strain gauges placed along the strut every 25cm equalling 7 strain gauges, this is because the strut appears to be under tensile stress and if the loads it is going to be subjected to are large enough it may elongate and the strain gauges will detect this in their placed position. The signal from the gauges would be amplified and sent to a concentrator; the signal would then go through an analogue to digital conversion ready to be sent to the microprocessor where it will be calculated with the modulus value of the strut to give the extension values. To determine the stress I will measure to strain and multiple it by the known modulus for mild steel (210GPa).



When using strain gauges to measure the stress in the load bearing strut, to maximise the measurement there are many factors and arrangements to consider when choosing suitable strain gauges. We must consider the type of strain the material is being subject to, so we know what the type of strain to measure such as axial bending shear or torsional. Once we have an idea we then consider the size and shape of the material that the strain gauge is going to be attached to as using strain gauges that have different widths of internal grid patterns, help with heat dissipation and enhance the stability. Strain gauges have a nominal gauge resistance that can be found in the data sheets. Using a strain gauge with a high nominal gauge resistance will help reduce heat caused by excitation voltage. The quality of measurement can be increased by the addition of more strain gauges throughout the length of the strut and possible on the other side of the strut. When installing the strain gauges, they must be bonded to the strut with the correct strain gauge adhesive to stop 'creep' which is where the gauge sometimes moves slowly or deforms under strain or vibration. There are different types of configurations the strain gauges can be arranged in commonly type 1 full bridge (Wheatstone bridge), 2 half bridge and 3 quarter bridge. Type one (full bridge) is the least sensitive to external influences e.g. temperature but requires three more strain gauges so maximising the quality of the measurement comes at a cost. ✓ 10

b)

Applying Loads of 1.5MN and 2.5MN to a strut that is 2m long and 100mm by 50mm width with a Modulus of Elasticity (210GPa).

Stress=Force/Cross sectional area

$$=1.5\text{MN}/100\text{mm}\times 50\text{mm}$$

$$=1.5\times 10^6/5\times 10^{-3}$$

$$\text{Stress} = 300\times 10^6\text{Nm}^2$$

$$\text{Modulus} = \text{Stress}/\text{Strain}$$

Therefore:

$$\text{Strain} = \text{Stress}/\text{Modulus}$$

$$=300\times 10^6\text{Nm}^2/210\times 10^9\text{Nm}^2$$

$$\text{Strain} = 0.001429$$

$$\text{Extension} = \text{Strain} \times \text{Length}$$

$$=0.001429\times 2\text{m}$$

$$\text{Elongation under } 1.5\text{MN} = 0.00286\text{m} \quad 2.86\text{mm} \quad \checkmark$$

The elongation of the strut under 2.5MN would be: The same process but with 2.5MN load that would give 0.00476m or 4.76mm elongation.

(BTEC Engineering Study Guide level 4,5, 2011) 7.

Task 2

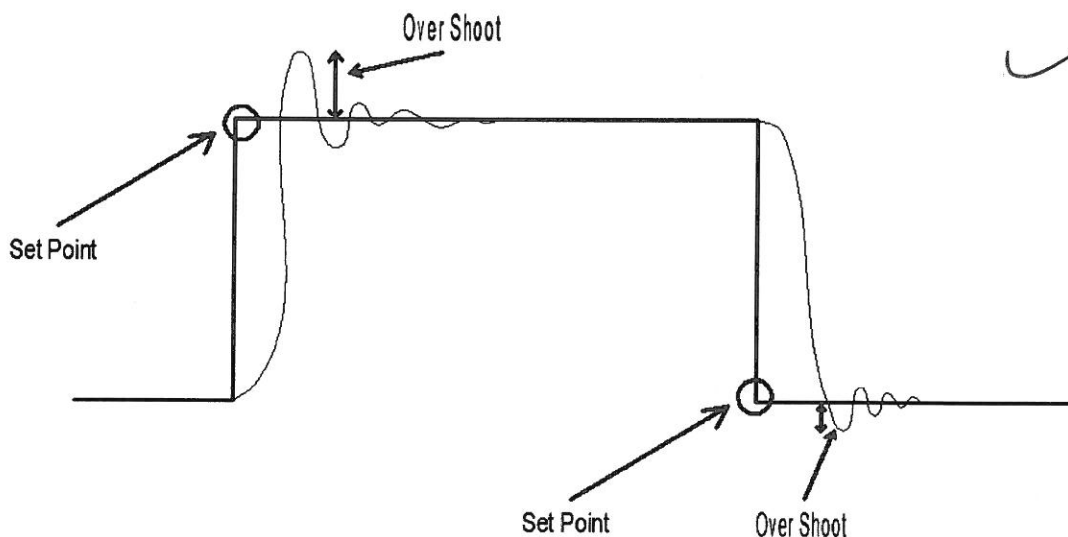
a) Set Point

In the context of control systems, a Set point is a target value that a controller tries to maintain. An example of this can be seen in a thermostatically controlled heating system in a modern domestic home, where a desired temperature is set. The desired temperature setting on the thermostat is the set point and any departure from this essential value through changes to the environment such as windows and doors being left open causing a temperature drop or rise will signal a change in power output to restore the set point temperature. The control system uses positive and negative feedback to automatically increase and decrease or turn off the power output around the essential value, give or take a couple of degrees in temperature. ✓

(Garrett-Dyke)

Overshoot

Overshoot is where a signal exceeds its target value/set point and its value is the amount that it exceeds the set point.



(W.Bolton, 1998)

Plant

Plant is also sometimes referred to as the System. To explain this, the simple open loop control system example of a car driving along a road; for the car to speed up the controller (driver) needs to activate the throttle that sends a signal to the Plant (engine) to increase power output for the car to increase speed. A closed loop system example of a Plant could be the gas heating control system in a house where the temperature is controlled by a thermostat sensor. If the desired temperature setting is reached, exceeded or falls below the controllers set point the thermostat will send a signal ✓

that in turn will send a signal to the plant (gas boiler) to increase output (burn gas) to bring the temp up or if the temp is reached or exceeded it will cease output and turn off (stop burning gas).

Control variable

This is a variable value that is under the control of the operator. It can be any component in a system that is predetermined E.g. a modern oven temperature setting, the speed a car is traveling or the level of liquid in a tank. ✓

Controller

The device that controls the system i.e. turns the power on/off, compares the values against the control variable and acts to maintain the control variable. ✓

Control Law

This is the algorithm or program that determines how the controller responds to the inputs. This is the relationship between the input and output. ✓ 10

b)

A transfer function represents the input output relationship for a system or component i.e. the ratio of the output to the input in the system. Every system that requires control has an input and an output, sometimes multiple input and outputs.

The transfer function block will contain all the equations relating to the system, such as motion, resistance, pressure, etc.



Example 1. The cruise control system in a car: The input comes from the throttle position, the transfer function is the car, or its engine and the output would be the speed. 6

Example 2. A domestic gas boiler: The thermostat setting is the input, then the gas is burned in the boiler, the transfer function and the temperature is the output.

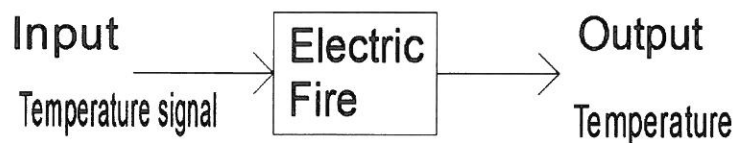
Example 3. A LP record player: The voltage input for the potentiometer or input speed, the system being the turntable and the speed that the turn table turns being the output.

Every system has an input output relationship and what sits between them is the transfer function.

c) Using examples, explain the key differences between 'open loop and 'closed loop' control systems.

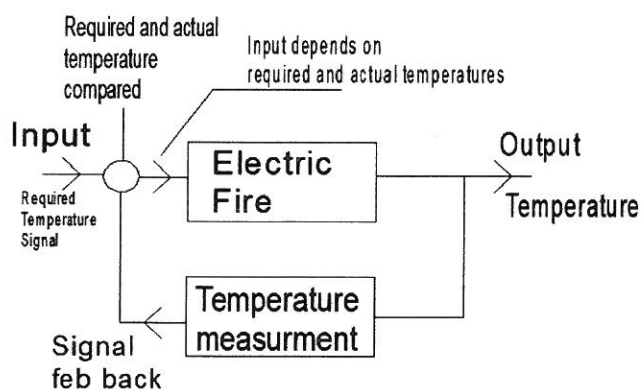
There are two types of control systems, open loop and closed loop.

Open loop control system.



An example of an open loop control system would be the control system for an electrical fire, it would typically have 2 switches, one for 1Kw heating element and another to switch to 2Kw (full power). Once activated this system will heat the surrounding area indefinitely regardless if the area is becoming extremely warm and exceeding a comfortable level and if this happens the system will require turning off manually. This type of system has no means of regulating the temperature in the surrounding area that it is heating, it has no feedback to regulate the system to turn it on or off if the area becomes too cold or becomes unbearably warm. So if disturbances take place, such as in this example, an opening of a window letting in cool air that brings the temperature down there is no change in the heat output.

Close loop



This system can measure monitor and control itself by sampling a small proportion of the output and feeding it back to compare the output temperature. The alteration to the open loop system to transform it into a closed loop system is the addition of the temperature sensor that will monitor the room temperature and compare it with the input reference. A small part of the signal at the output is sent via (feedback) to the temperature compare device where the signal is compared to the input

and the error is used to determine if the system is still required to stay on or switch off. This system is designed to achieve and maintain a desired output in this case the temperature.

b)

A close loop system will outperform an open loop system. If we look at the previous open and closed loop example in part C. The open loop system that is not temperature controlled has no means of reacting to disturbances, this was shown when a window or door is opened, and cool air lowers the room's temperature and the system remains at the same output. The closed loop system would detect the change in temperature and reacting to increase output to bring the room up to a higher temperature. So you could say that the closed loop system is less sensitive to disturbances because it can detect them and react accordingly to achieve and maintain a desired variable value. Also the closed loop system can control temperatures over wide range temperature settings where the open loop example has only pre-set output values 1 or 2KW's. ✓

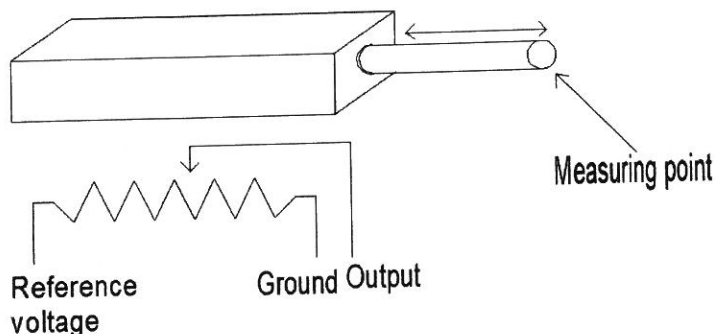
(W.Bolton, 1998)

Task 3

a)

- Linear displacement

A Linear Variable distance transducer LVDT would be used to measure a linear displacement in the form of an analogue signal. For example, a linear potentiometer would use a resistance to measure the linear displacement of an object.



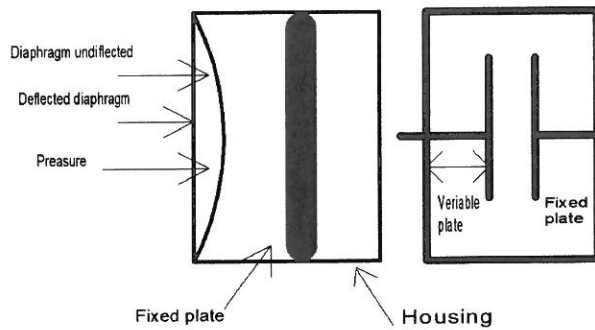
The object is attached to the measuring point and as the object moves it changes the position on the wiper and this will change the voltage, and this can be measured. ✓

- Rotational displacement

An incremental rotary encoder will report rotational displacement and direction. There are many types. Optical, magnetic being the main types. ✓

- Pressure

A diaphragm type transducer that measures pressure by using strain gauge of capacitive sensitivity. As increase in pressure causes the diaphragm to deflect in towards the other plate the capacitors capacitance value changes and this can be measured and a value in relation to pressure can be formulated. ✓



- Presence (of metallic item)

An inductive sensor would detect changes in inductance due to the presence of a metallic item. This is due to the change in the magnetic field around the sense coil. ✓ 1

- Vibration

There are many different types of transducers to measure vibration. A microphone is a transducer that converts acoustic energy/sound waves into electrical energy, an audio signal. Sound waves vibrate a diaphragm that is a thin piece of material that is housed in the microphones head. This produces a current when sound vibrations move the sensitive piece of material this can be used to produce a signal. ✓ 2

b) A 4-20mA transducer would be a current loop system with low impedance that is less likely to be affected by interference. A 0-10 volt transducer is a high impedance voltage system that is more susceptible to interference. ✓ 2

Task 4

a) The term 'stability' in relation to control systems means that the systems output remains stable or returns in equilibrium after it has been subjected to a bounded input or a disturbance. A system with good stability when subjected to bounded input or disturbance being of a limited size (finite size) should not cause the system to continue changing indefinitely. A condition of stability is where the systems output returns to zero or the set point. ✓ S.

b)

$$(1) \quad \frac{(S+4)(S-1)}{(S+4)(S+2)(S+3)}$$

Using FOIL method to work out Numerator and Denominator for Mat Lab formula.

Numerator:

$$(S+4)(S-1) \\ = S^2 - 1S + 4S - 4$$

Denominator:

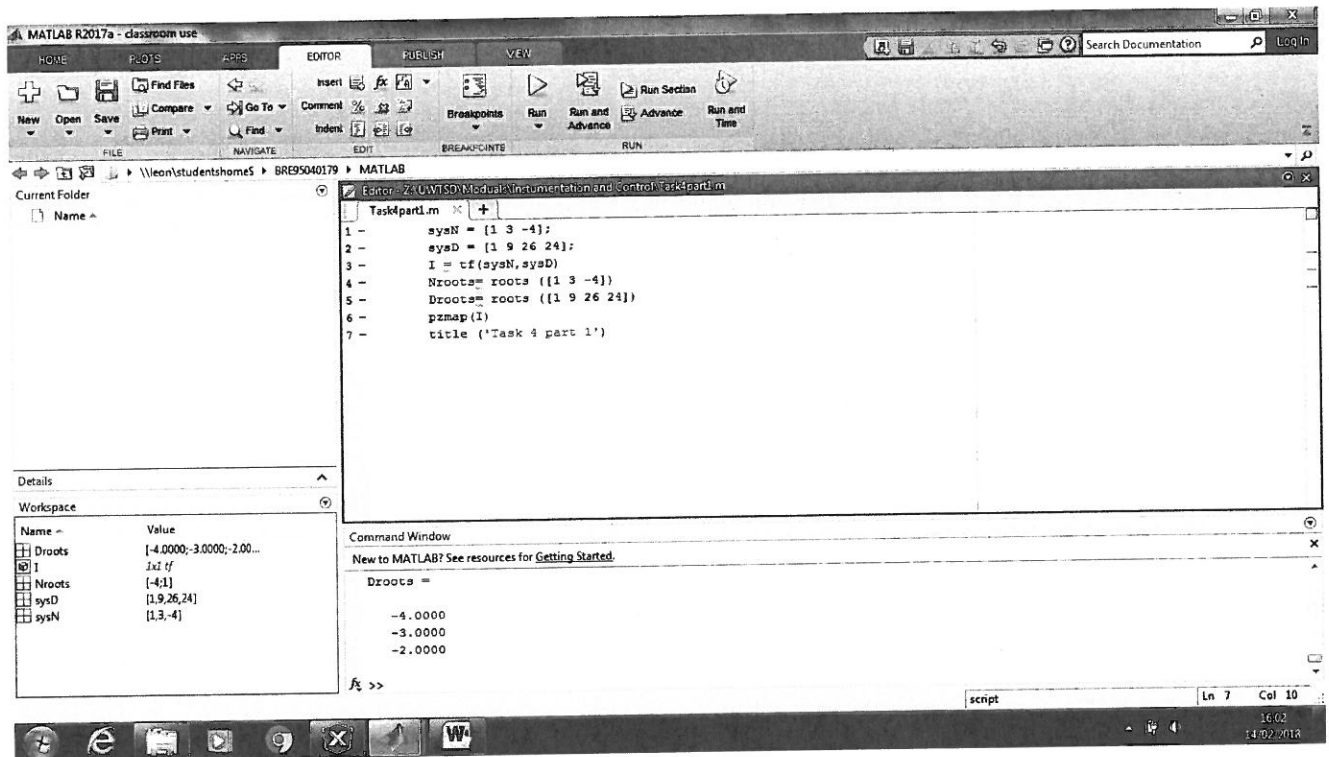
$$(S+4)(S+2)(S+3) \\ S^2 + 2S + 4S + 8 \\ 5^2 + 6S + 8 \\ (S)(S^2 + 6S + 8) = (S^2 + 6S^2 + 8S) \\ (+3)(S^2 + 6S + 8) = +3S^2 + 18S + 24$$

So

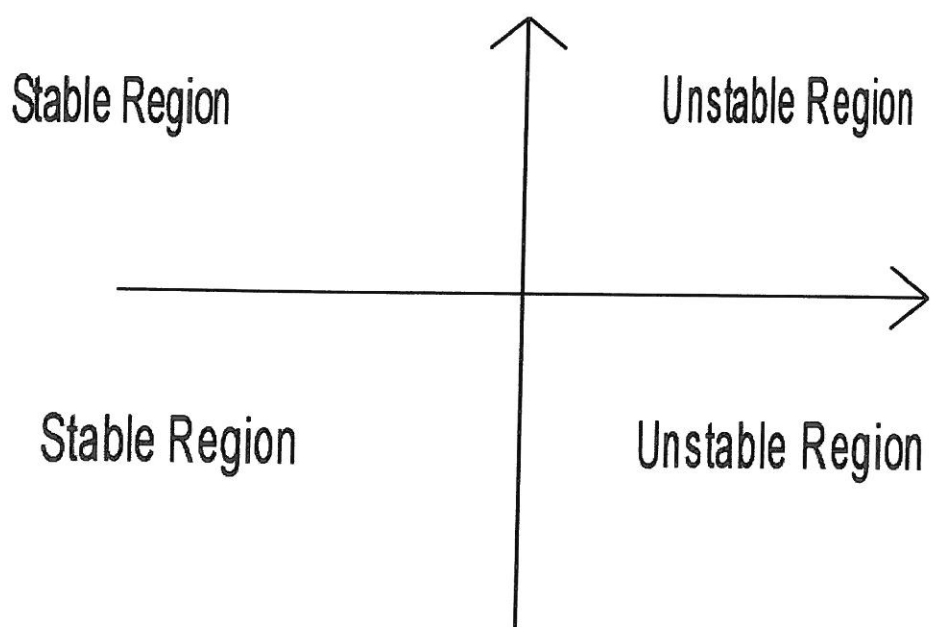
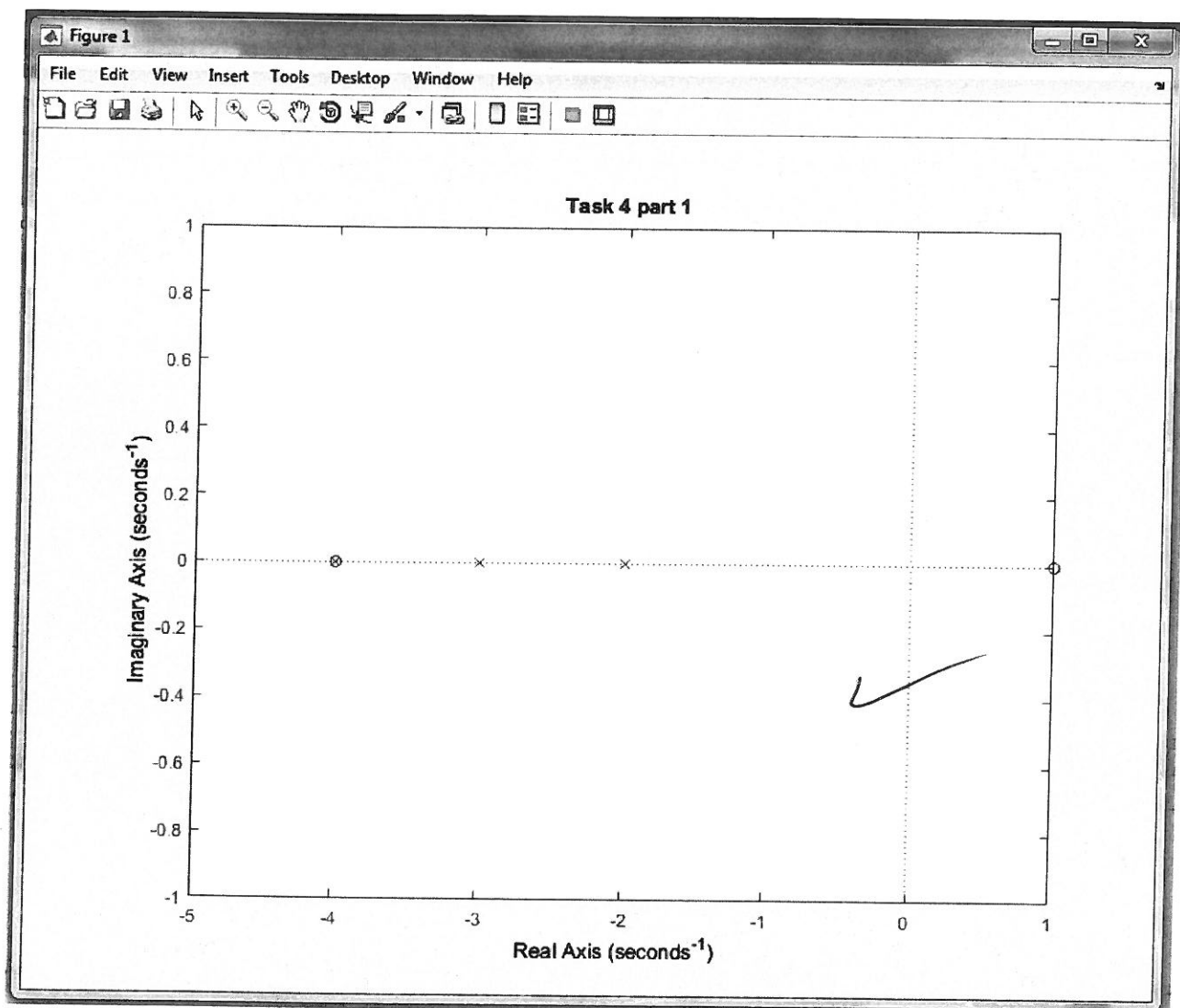
$$5^3 + 6S^2 + 8S + 3S^2 + 18S + 24$$

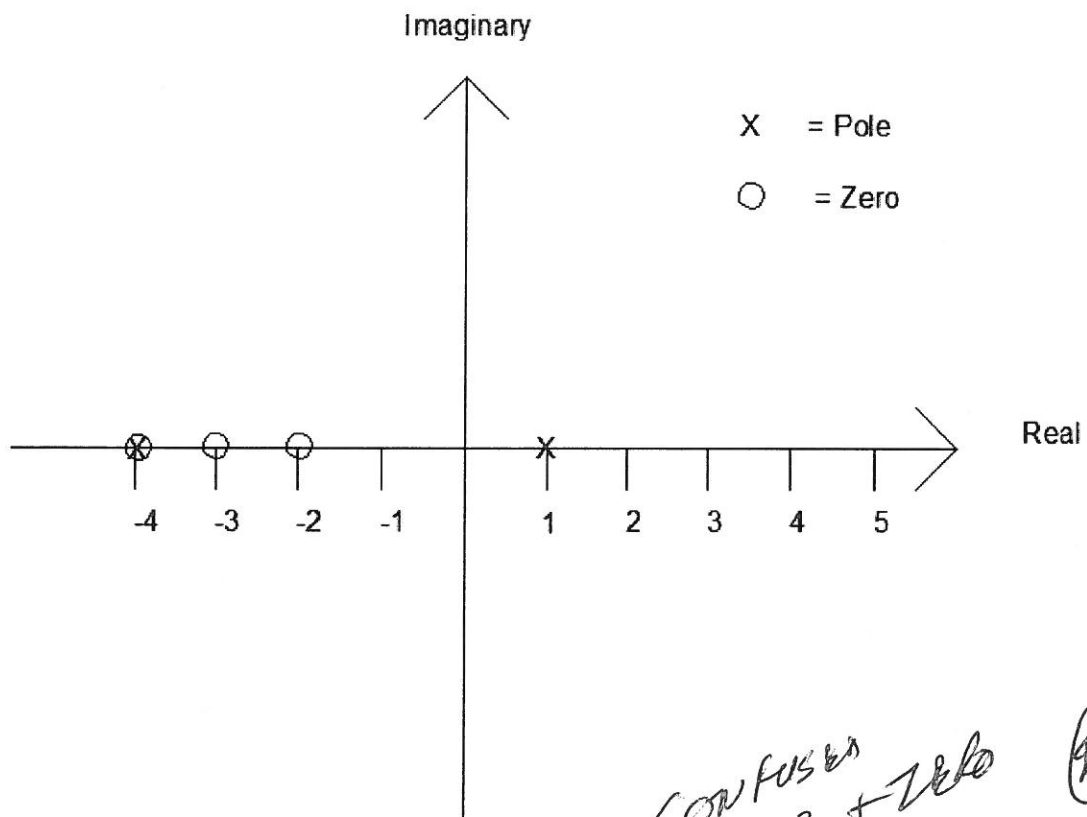
Denominator

$$= 5^3 + 9S^2 + 26S + 24$$



S Plane





*CONFUSION
POLE + ZERO*

A system with a characteristic of this one is unlikely to be stable due to the pole on the right-hand side S plane.

(2) $\frac{(S-2)}{S(S+1)(S+4)}$

Using FOIL method to work out Numerator and Denominator for Mat Lab formula.

Numerator:

$$(S-2)$$

$$= 1 - 2$$

Denominator: $S(S+1)(S+4)$

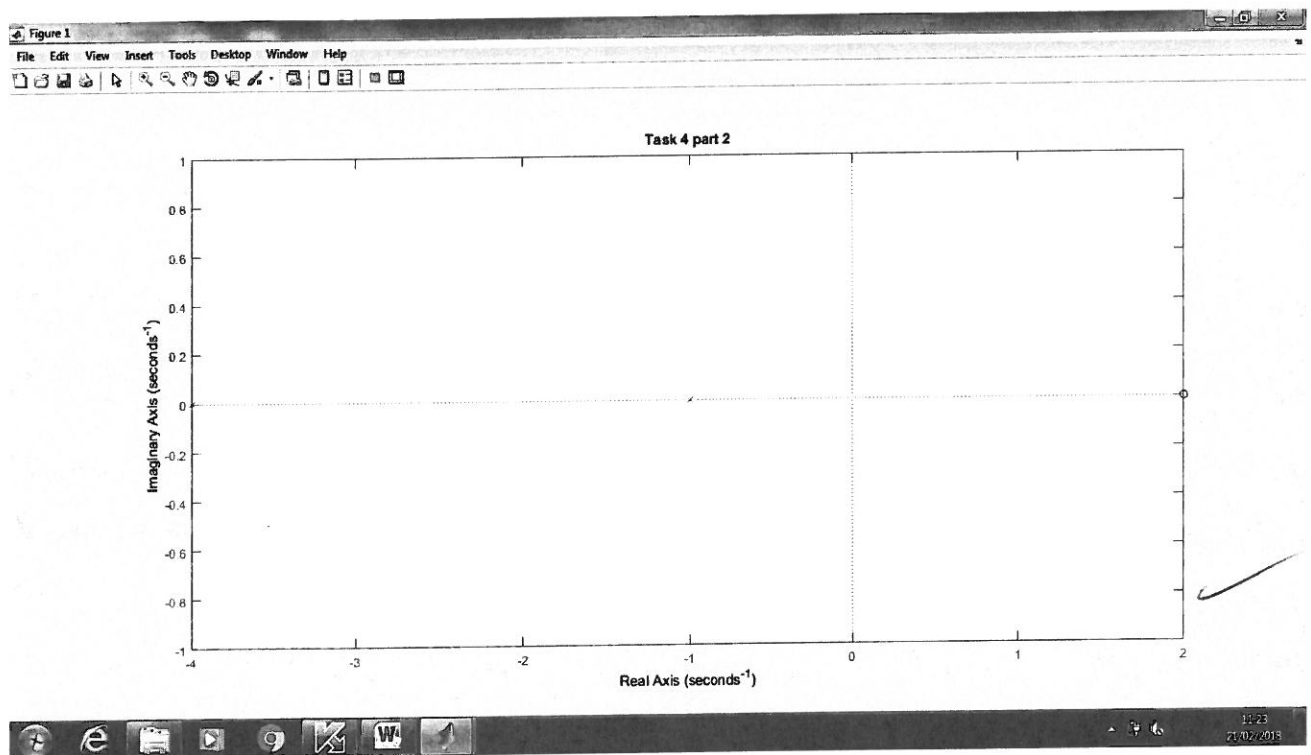
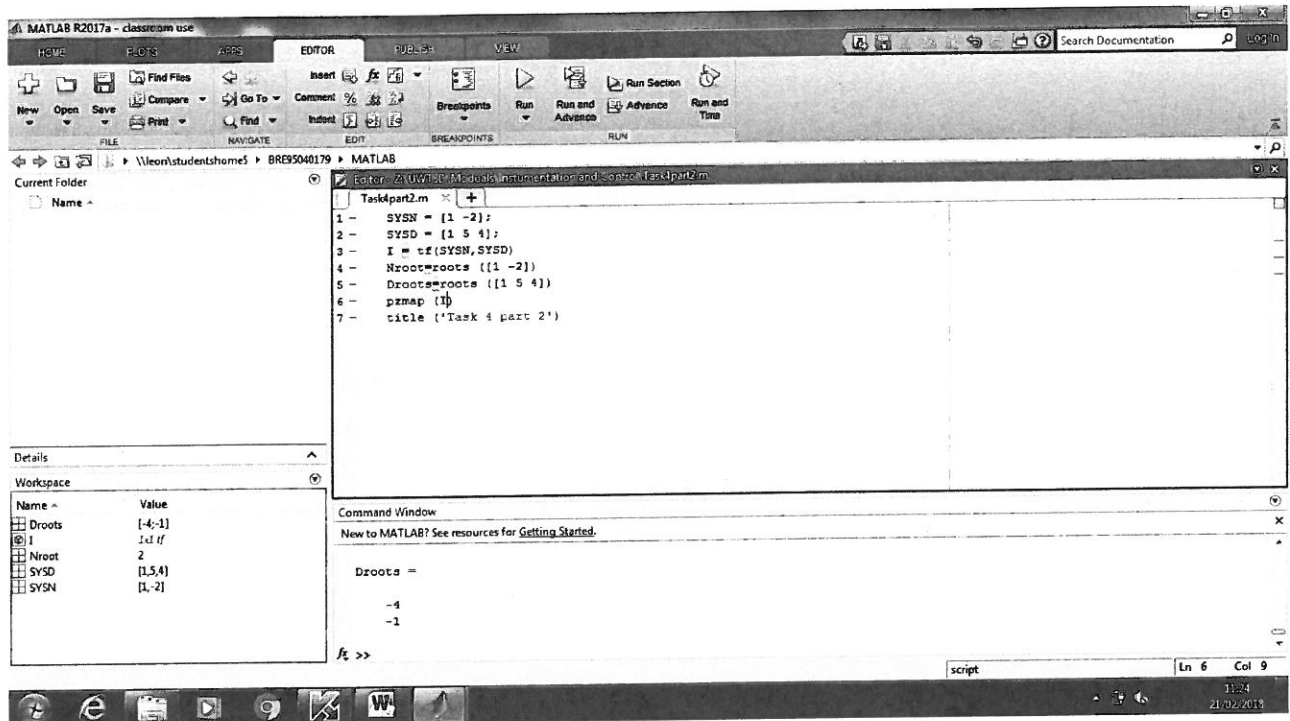
$$(S^2 + 5)(S + 4)$$

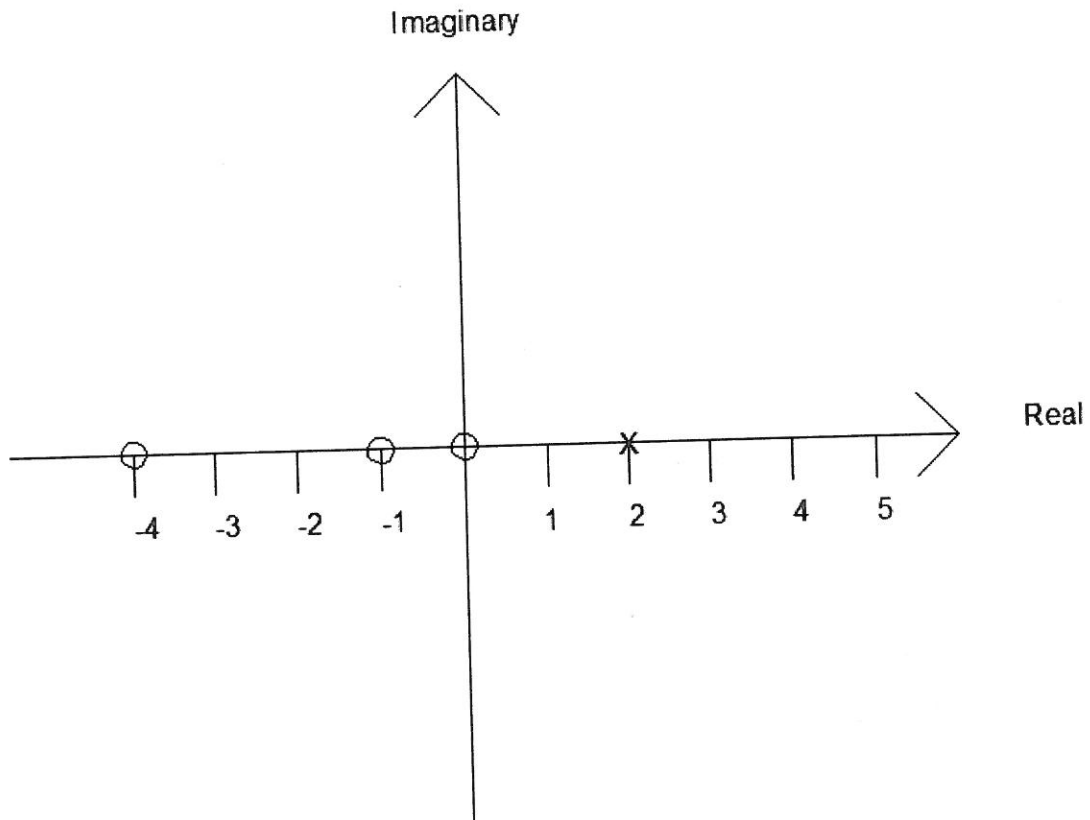
$$S^3 + 4S^2 + 5S^2 + 4S$$

$$S^3 + 5S^2 + 4S$$

$$= S^3 + 5S^2 + 4S$$

So values are 1, 5, 4.

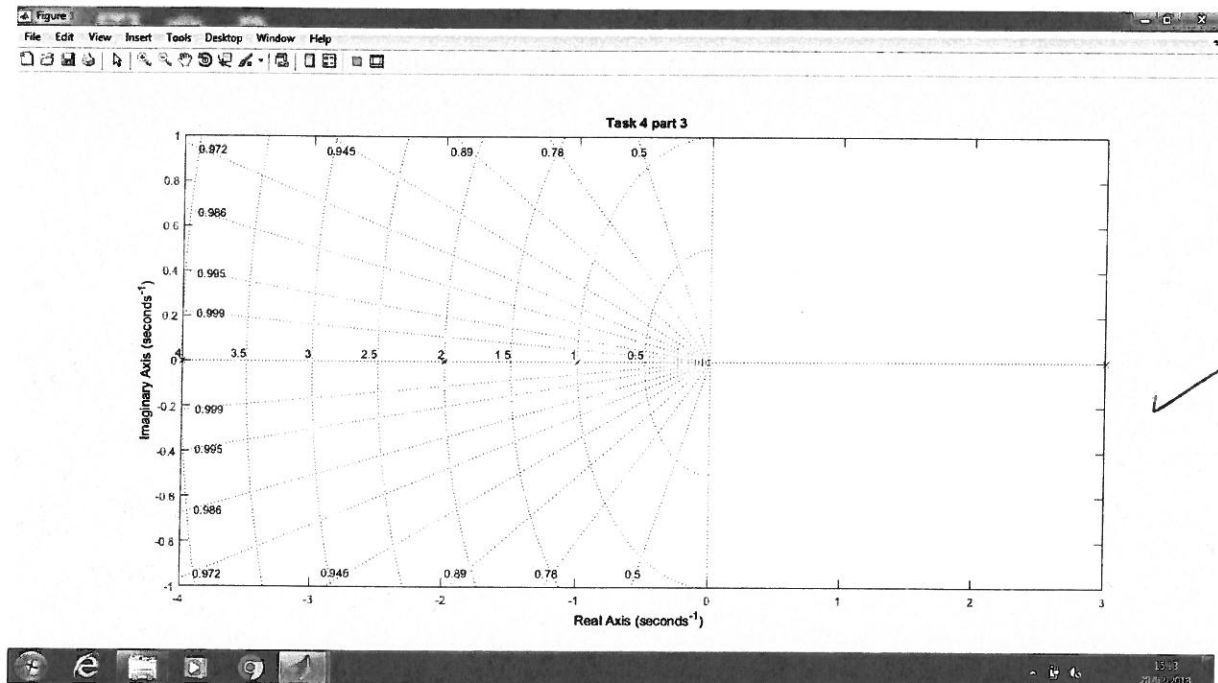
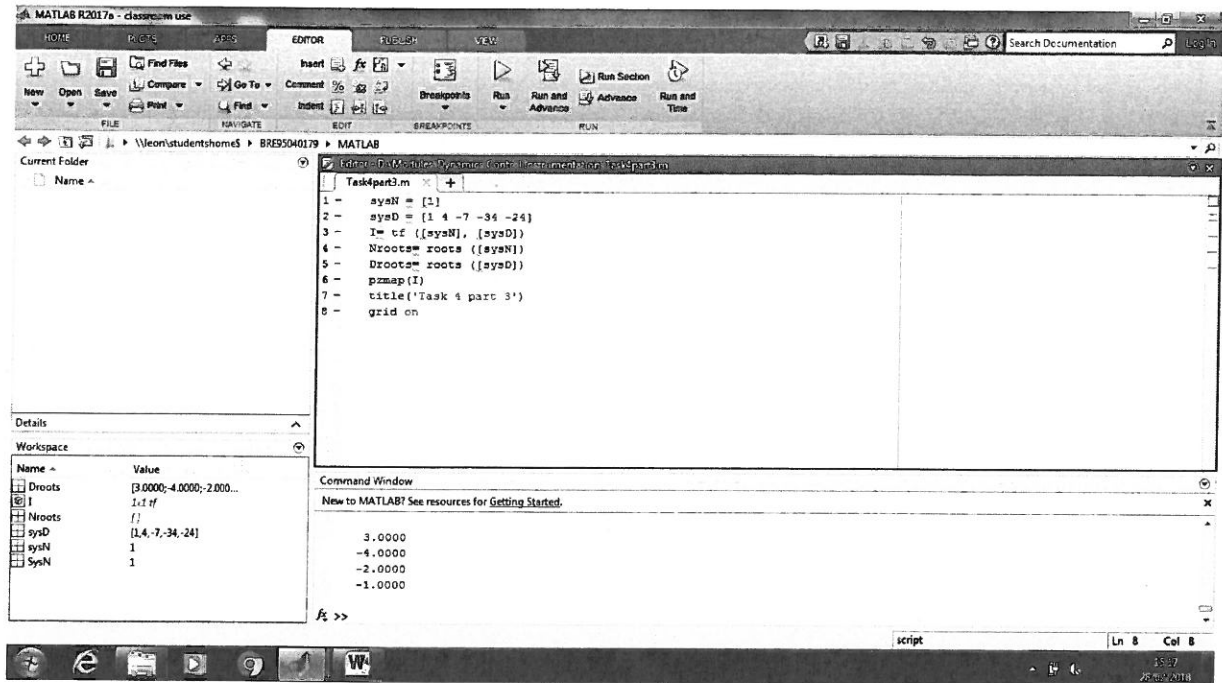




A system with a characteristic of this one is unlikely to be stable due to the pole on the right-hand side S plane.

(3) $s^4 + 4s^3 - 7s^2 - 34s - 24 = 0$

Denominator [1+ 4 -7 -34 -24]



Factorise to find if stable or unstable.

$$S^2 + 4s^3 - 7s^2 - 34s - 24 = 0$$

$$(S+2)(S^3 + 2S^2 - 11s - 12)$$

$$S^3 + 2S^2 - 11s - 12$$

$$(S+2) \sqrt{\frac{S^3 + 2S^2 - 7s^2 - 34s - 24}{S^4 + 2S^2}}$$

$$2s^2 - 7s^2$$

$$\underline{2s^2 + 4s^2}$$

$$-11s^2 - 34s$$

$$\underline{-11s^2 - 22s}$$

$$-12s - 24$$

$$\underline{-12s - 24}$$

$$0$$

(S+2) is a factor.

$$S^3 + 4s + 3$$

$$(S-2) \sqrt{\frac{S^3 + 2S^2 - 11s - 12}{S^4 - 2S^2}}$$

$$4s^2 - 11s^2$$

$$\underline{4s^2 + 8s^2}$$

$$3s - 12s$$

$$3s - 6s$$

(S-2) is not a factor.

$$S^3 + 5s^2 + 4$$

$$(S-3) \sqrt{\frac{S^3 + 2S^2 - 11s - 12}{S^3 - 3S^2}}$$

$$+5s^2 - 11s$$

$$\underline{5s^2 - 15s}$$

$$4s - 12s$$

$$\underline{4s - 12}$$

$$0$$

(S-3) is a factor.

$$S^4 + 4s^3 - 7s^2 - 34s - 24$$

$$= (S+2)(S-3)(S^2+5s+4)$$

$$(S^2+5s+4)$$

$$a=1 \quad b=5 \quad c=4$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{-5 \pm \sqrt{(5)^2 - 4(1)(4)}}{2(1)}$$

$$-4 \text{ or } -1$$

$$(S+4)$$

$$(S+1) \sqrt{\begin{array}{r} S^2 + 5s + 4 \\ S^2 + s^2 \end{array}}$$

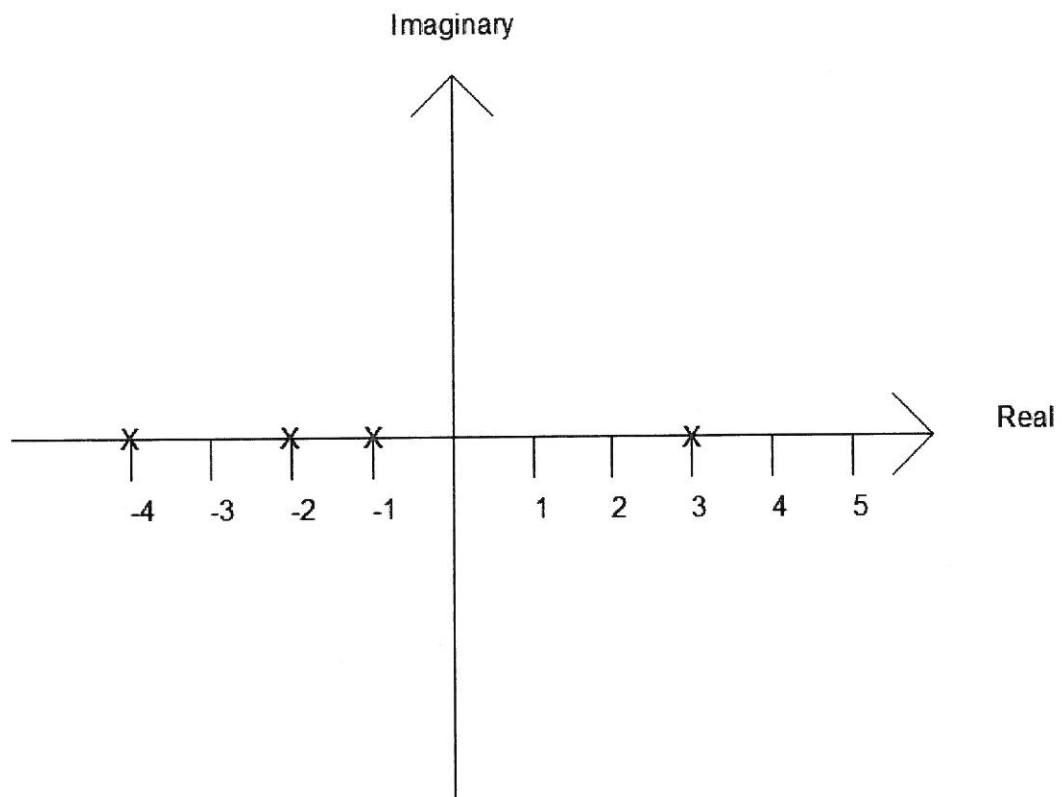
$$4s+4$$

$$\underline{4s+4}$$

$$0$$

The factors of $S^2 + 4s^3 - 7s^2 - 34s - 24 = 0$ are (S+1) (S+2) (S-3) (S+4)





A system with a characteristic of this one is unlikely to be stable due to the pole on the right-hand side S plane.

(4) 8.

References

BTEC Engineering Study Guide level 4,5. (2011). A Pearson Company.

Garrett-Dyke, C. (n.d.). *Temperature Control Blog by West Control Solutions*. Retrieved February 2018, from West control solutions: <http://blog.west-cs.com/blog/understanding-setpoints-in-temperature-control>

W.Bolton. (1998). *Industrial Control & Instrumentation*. Pearson Education.

