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Dynamics Control and Instrumentation

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STRUCTURE

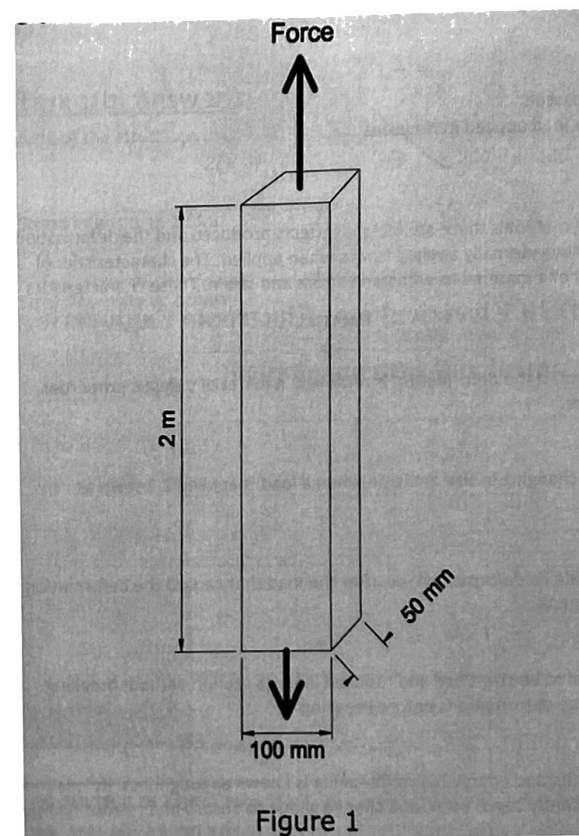
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Task 1(a) - Question

It is required to determine the stress in a load bearing strut as depicted in Figure 1:



Propose a measurement system to determine the strain experienced by the strut. Explain Stress and Strain in the context of a force applied directly to the strut. Explain any special arrangements to maximise the accuracy of and hence confidence in the measurements.

Task 1(a) - Answer

The unit of measurement that will be used is Pascal's, how ever the measurement on its own will be too small in an engineering application however it can be shown in Kilopascal (kPa) and megapascals (MPa), pascals or pressure is worked out by dividing force measured in newtons (N) and the area of an object (m^2).

= -

P = stress intensity measured in pascals

P = the parallel or perpendicular load applied in Newtons

A = area in M^2

(Awari, 2022)

When strength and stress testing materials there are internal effects produced and the deformations of bodies that are usually caused by externally applied forces when applied. The characteristics of the material will affect the ability of a material to withstand stress and strain. These characteristics are:

Elasticity

When a force or pressure that caused the deformation is removed, a material's elastic properties allow it to regain its original shape.

Stiffness

The ability of a material to resist changing in size or shape when a load is applied is known as stiffness.

Plasticity

The ability of a material to maintain its deformed shape after the load that caused the deformation is removed is known as plasticity.

Ductility

Ductility is the ability of a material to be stretched and reduced in cross section without breaking. Ductile materials will undergo large deformations before breaking

Toughness

The capacity of a substance to withstand energy before breaking is known as toughness. Before they break, tough materials will significantly bend, twist, and change shape to absorb and release energy..

Brittleness

Materials that are brittle fracture with little to no prior deformation. Hardness A material's capacity to withstand penetration is referred to as hardness.

Stress

Stress is characterised as the internal resistance that a material develops in response to an applied load or external force. Force per unit area resisting the force is how stress is calculated.
(ranonseemshahid, 2022)

Task 1(b) Question

Demonstrate the performance of your system when loads of 1.5MN and 2.5MN are applied. Assume the strut is of steel construction to the dimensions shown in figure 1, with a Modulus of Elasticity (E) of 210Gpa.

Task 1(b) Answer

Area of the strut:

$$2(\quad + \quad) = 2(5^2 + 200^2 + 100^2) = 610^2$$

Stress intensity at 1.5Mn

$$\frac{1500000}{610} = 2,459 = 2,459$$

Stress intensity at 2.5Mn

$$\frac{2500000}{610} = 4,089 = 4,098$$

②

②

Task 2 (a) Question

Provide a definition of the following terms:
Displacement, Velocity, Acceleration.
Support your answer by figures and mathematical expressions. What is the relationship between them?

Task 2(a) AnswerDisplacement

If an object moves relative to a reference frame—for example, if a professor moves to the right relative to a whiteboard, or a passenger moves toward the rear of an airplane—then the object's position changes. This change in position is known as displacement. The word displacement implies that an object has moved, or has been displaced.

Displacement is defined to be the change in position of an object. It can be defined mathematically with the following equation:

(Academy, 2022)

$$\Delta = -0 \quad ?$$

Acceleration

Any procedure where the velocity varies is referred to as acceleration. There are only two ways to accelerate: changing your speed or changing your direction, or changing both. This is because velocity is both a speed and a direction.

Your understanding of velocity and its scientific meaning are probably comparable. You are aware that a big displacement over a short period of time corresponds to a large velocity, and that velocity is measured in terms of the speed of objects in terms of miles per hour or kilometres per hour. Acceleration can be defined by the following mathematical equation:

(Academy, 2022)

$$= -$$

Velocity

Your understanding of velocity and its scientific meaning are probably comparable. You are aware that a big displacement over a short period of time corresponds to a large velocity, and that velocity is measured in terms of the speed of objects in terms of miles per hour or kilometres per hour. The change in position divided by the distance travelled is how average velocity is calculated. The equation is listed below:

$$= -$$

(Academy, 2022)

Task 2 (b) Question

The position coordinate of a particle which is confined to move along a straight line is given by $s = 3t^3 - 24t + 6$, where s is measured in meters from a convenient origin and t is the time in seconds. Determine:

- The time required for the particle to reach a velocity of 60 m/s from its initial condition at $t=0$.
- The acceleration of the particle when $s = 35$ m/s.
- The net displacement of the particle during the interval from $t=2$ s to $t=4$ s.
- Draw the path of the particle between $0 < t < 5$ s.

Task 2 (b) Answer

- First you need to find the derivative of the displacement to get the velocity (v) of the particle, then solve to get the time (in seconds)

$$60 \text{ m/s} = 12t^2 - 24$$

$$84 = 12t^2$$

$$t^2 = 7$$

$$60 = 9t^2 - 24$$

$$t = 2.64 \text{ seconds}$$

- First you need to find the derivative of the displacement to get the velocity (v) then find the time when velocity is at 35 m/s then derive the velocity to get acceleration and multiply the time by the derivative to get the acceleration

$$35 \text{ m/s} = 12t^2 - 24$$

$$59 = 12t^2$$

$$t = 2.22 \text{ s}$$

$$a = 24t$$

$$v = 9t^2 - 24$$

- First you need to work out the displacement at $t=2$ then $t=4$ then subtract them to get the next displacement.

$$s = 3t^3 - 24t + 6$$

$$s = 3(2)^3 - 24(2) + 6 = -18 \text{ M}$$

$$s = 3(4)^3 - 24(4) + 6 = 102 \text{ M}$$

$$s = 102 - -18 = 120 \text{ M}$$

- First you need to substitute the time into the displacement formula from $t=0$ to $t=5$ then plot them in an distance time graph

$$t = 0 \quad s = 3(0)^3 - 24(0) + 6 = 6 \text{ M}$$

$$t = 1 \quad s = 3(1)^3 - 24(1) + 6 = -15 \text{ M}$$

$$t = 2 \quad s = 3(2)^3 - 24(2) + 6 = -18$$

$$t = 3 \quad s = 3(3)^3 - 24(3) + 6 = 15$$

$$t = 4 \quad s = 3(4)^3 - 24(4) + 6 = 102$$

$$t = 5 \quad s = 3(5)^3 - 24(5) + 6 = 261$$

Task 3 Question

Control systems are often characterised as being Open loop or Closed loop.

a) Explain the key differences between these two terms.

b) Compare the key operational differences between open and closed loop systems. This should include a mathematical analysis of the impact to the system output due to component variation and disturbances.

c) Provide an explanation of the following terms (illustrate with suitable examples):-

- Overshoot
- Non-touching loops
- Plant
- Settling Time
- Steady state error
- PID

Task 3 Answer

(a) The difference between closed and open loop control systems

Because a closed-loop system has the ability to self-correct itself while an open-loop system does not, closed-loop systems are frequently referred to as feedback control systems and open-loop systems are frequently referred to as non-feedback control systems.

(Yalcin, 2022)

(b) Comparison table

<u>Open loop control system</u>	<u>Closed loop control system</u>
In an open loop system, the control action is independent of the output	The output of this system depends on a controlled act of the system
An open loop control system can also be referred to as a non-feedback control system	The closed loop control system is also known as a Feedback control system
The controlled process and controller are examples of components in this system.	An example of some components in this system include feedback and an amplifier
This system is easy to build	The closed loop system can be difficult to construct
The open loop systems consistency is not reliable	The closed loop systems is consistent
Calibration determines the accuracy of open loop systems	The closed loop system is very accurate due to the feedback component
The open loop system is a stable system	The closed loop system is unstable
this system can't be optimised	You can optimise this system
The open loop system is a responsive system	The closed loop system isn't very responsive
This system is difficult to calibrate	This system is easy to calibrate
This system isn't linear	These systems are linear
This control system can be seen in things like a traffic light and a TV remote	This control system can used for things like an ACs, control system

(Difference Between Open Loop & Closed Loop System (with Comparison Chart) - Circuit Globe, 2022)

(c)

Overshoot

The amplitude of the first peak corresponds to overshoot, which is the response's maximum overshoot of the steady-state value. $Q=(1/2)$ is the formula to calculate the overshoot. (Bolton, 2022)

Plant

The plant is the product of mechanical inefficiencies and factors like gravity and friction. The system plant typically changes over time in situations like a car going up and down hills as it drives along a road or a robot moving from a carpeted floor to a smooth concrete floor. (Juršić, 2022)

Setting time

The output of a control system that changes over time in response to an input is known as the time response of the control system. Transient reaction and steady state response are the two components of the temporal response.

(Control Systems - Time Response Analysis, 2022)

Steady state error

The difference between the desired and actual values as time approaches infinity is referred to as an output of a system in the limit (i.e., when the control system has reached steady-state). Input/output response of a linear system is known as steady-state error.

PID

PID controllers are used in industrial control applications to control process variables including flow, pressure, speed, and temperature. A PID (proportional integral derivative) controller uses a control loop feedback mechanism to regulate process variables. The most precise and reliable controllers are them.

(Engineering, 2022)

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