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Internal Assessment Test 2 – Nov. 2017

Sub:	Automation & Robotics					Sub Code:	15ME563	Branch:	ECE/ISE
Date:	09.11.17	Duration:	90 min's	Max Marks:	50	Sem / Sec:	V/A&B		

Answer any FIVE FULL Questions

		MARKS	OBE CO	OBE RBT
1	With respect to Robot drive system, discuss about the following parameters (i) Speed of motion (ii) Load carrying capacity	[10]	CO2	L2
2	Explain the following (i) Spatial resolution (ii) Repeatability	[10]	CO2	L2
3	Derive the mathematical model for spring mass damper system, draw the block diagram for the same and also reduce it to the single block.	[10]	CO3	L2
4 (a)	Differentiate between a controller and actuator.	[04]	CO3	L2
(b)	Discuss briefly about the following controllers (i) P-D controller (ii) P-I-D controller	[06]	CO3	L2
5	Define transient response of the system; also define (i) Delay time (ii) Rise time (iii) Peak time (iv) Settling time.	[10]	CO3	L2
6.(a)	With a neat sketch describe optical encoders.	[06]	CO3	L2
(b)	Discuss any one power transmission elements used in robotics.	[04]	CO3	L1
7.	Discuss any one application of Tactile array sensors with an example.	[10]	CO4	L2

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AUTOMATION & ROBOTICS

1) (i) Speed of Motion

-) The speed of motion determines how quickly the robot can accomplish a given work cycle.

-) It is generally desirable in production to minimize the cycle time of a given task.

-) Determination of the most desirable speed in addition to merely attempting to minimize the production cycle time would also depend on other factors such as

(i) The accuracy with which the wrist must be positioned

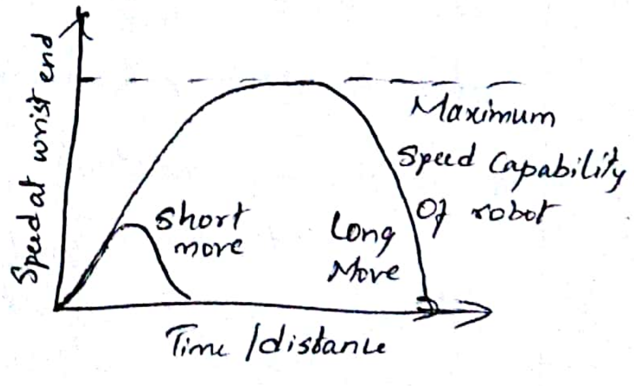
Accuracy is inversely proportional to the speed of motion of the robot. If higher accuracy is required then the speed must be lower

(ii) The weight of the object being manipulated

Heavier the object being manipulated means greater inertia & momentum so the robot must be operated slowly to safely deal with these factors

(iii) The distance to be moved

Because of acceleration & deceleration problem robot is capable of moving longer distances in less time compared to sequence of short distances



(ii) Load carrying capacity

load carrying capacity of robot depends on the size, configuration, construction & drive system of the robot.

Generally the load carrying capacity should be specified under the condition of robot arm in its weakest position ie... under maximum extension condition

The weight carrying capacities of industrial robots ranges from less than a kilogram for some of the small scale robots upto several hundred kilograms for very Large scale robots.

If robot has rigid construction as in cartesian configuration they can handle heavy weights

If the robot has ~~heavy~~ hydraulic drive system compared ~~the~~ to pneumatic can handle heavy weights.

(2) (i) Spatial resolution :- It is the smallest increment of movement into which the robot can divide its work volume

It depends on two factors

(a) System's control resolution

(b) Robot's mechanical inaccuracies.

(a) System's control resolution

→ It is a feedback measurement system which determines the robot's position

→ It is the controller's ability to divide the total range of movement into individual addressable points that can be stored in control memory.

→ The number of separate, identifiable increments for a particular axis is given by 2^n

n = the number of bits in the control memory.

(b) Robots mechanical inaccuracies

Mechanical inaccuracies come from elastic deflection in structural members, gear backlash, stretching of pulley belts, leakage of hydraulic fluids & other imperfections.

These inaccuracies tend to be worse for larger robots simply because errors are magnified by the larger components.

(ii) Repeatability :- It is concerned with the robot's ability to position its wrist or an end effector at a point in space that had previously been thaught to the robot.

It refers to the robot's ability to return to the programmed point when comanded to do so.

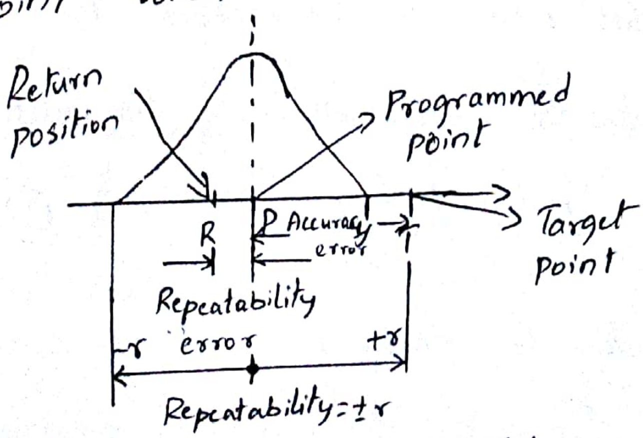


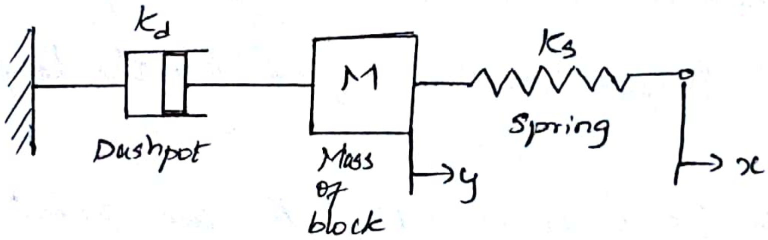
Illustration of repeatability

During teach procedure, the robot is commanded to move to point T, but because of the limitations on its accuracy the programmed position becomes point P.

Subsequently the robot is instructed to return to point P however it returns to position R. The difference between P & R is a result of limitations on the robot's repeatability.

Repeatability errors form a random variable & constitute a statistical distribution like a symmetric bell shaped distribution curve.

(3)



$y \rightarrow$ displacement of mass

$x \rightarrow$ The displacement of the end of the spring.

Spring mass damper system

The system consists of a block with certain mass 'M' suspended from a fixed wall by a dashpot at one end and the other end is connected to a spring.

The force due to acceleration of the mass is

$$F_M = M \frac{d^2y}{dt^2} \quad \ldots \rightarrow (1)$$

The force due to dashpot is

$$F_d = k_d \frac{dy}{dt} \ldots \rightarrow (2)$$ $k_d \rightarrow$ Damping coefficient

The force due to the springs is

$$F_s = K_s y - K_s x \; \cdots \to \; (3)$$

Summing the equation (1), (2) & (3)

$$M\frac{d^2y}{dt^2} + K_d \frac{dy}{dt} + K_s y - K_s x = 0$$

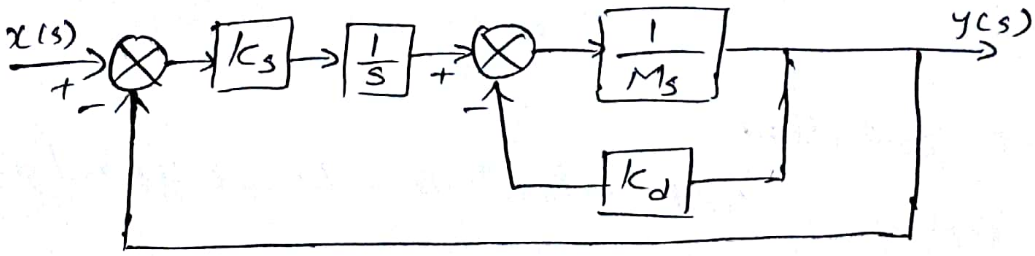
$$\boxed{M\frac{d^2y}{dt^2} + K_d \frac{dy}{dt} = K_s x \; \cdots \to \; (4)} \to \text{Mathematical model of Spring mass damper system.}$$

Laplace transform using operator 's' for equation (4)

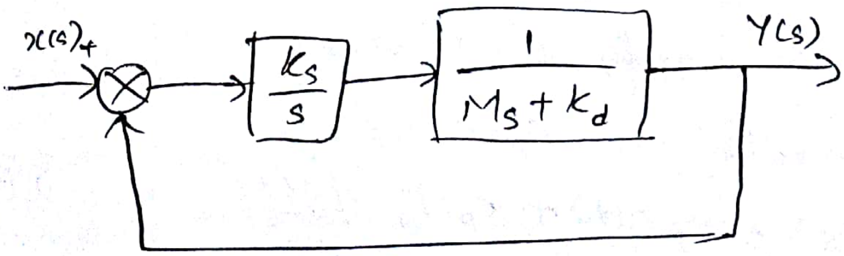
$$M s^2 Y(s) + K_d s Y(s) + K_s Y(s) = K_s X(s) \; \cdots \to \; (5)$$

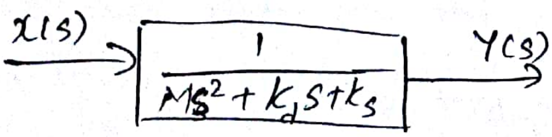
The transfer function relates output of the system to an input

$$\boxed{\frac{Y(s)}{X(s)} = \frac{K_s}{M s^2 + K_d s + K_s}} \to \text{Transfer function of Spring mass damper System}$$



Block diagram for spring mass damper system





(4) a)

Controller	Actuator
(i) Controller is a component which takes input from sensors & decides what command to send the actuators to achieve the intented behaviour of the system	(i) Actuator is component of a machine or system which is responsible for the movement of a part or mechanism of the system. ~~Ex reciever~~
(ii) There are 6 types of controllers (a) on-off (b) Proportional (c) Integral (d) Proportional plus integral (e) Proportional plus derivative (f) proportional plus integral plus derivative	(ii) In general their are 3 types of actuators (a) hydraulic (b) pneumatic (c) Electric

~~4~~ (b)

4) (b) P-D controllers

Derivative controller action provides a control signal proportional to the rate of change of error signal. Since this would generate no output unless the error is changing, it is rarely used alone.

The P-D controller is represented by

$$m(t) = k_p e(t) + k_p T_d \frac{de(t)}{dt} \quad \text{---} \rangle \ (1)$$

& the transfer function is

$$\frac{M(s)}{E(s)} = k_p(1 + T_d s)$$

(ii) PID controller :- P.I.D controller is the most general controller type & probably the most commonly used type of controller. It provides quick response, good control of system stability & low steady-state error. As it is the combination of 3 types of controllers i.e.. proportional plus derivative & Integral controllers.

The PID controller can be represented by

$$m(t) = k_p e(t) + \frac{k_p}{T_i} \int e(t)\,dt + k_p T_d \frac{de(t)}{dt}$$

& the transfer function is

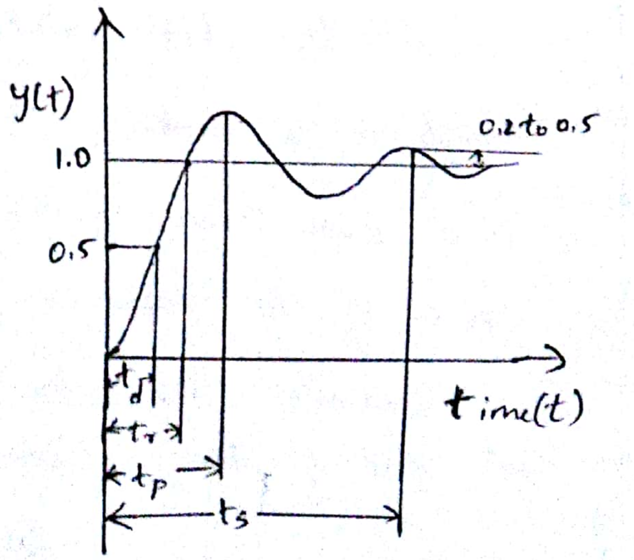
$$\frac{M(s)}{E(s)} = k_p \left(1 + \frac{1}{T_i s} + T_d s\right)$$

k_p → proportionality gain

T_i → Adjusts the integrator gain

T_d → Adjusts derivative gain

(5) The transient response of a system is the behavior of the system during the transition from some initial state to the final state



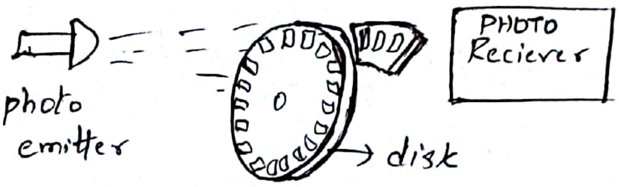
(i) Delay time (t_d):- Delay time is the time that it takes the system to reach one half of the final value for the first time.

(ii) Rise time (t_r) :- Rise time is the time the system takes to go from 10 to 90 percent. or 5 to 95 percent of the final value

(iii) Peak time (t_p) :- It is the time which the system takes to reach maximum overshoot for the first time.

(iv) Settling time (t_s) :- Settling time is the time ~~the~~ required for the system ~~takes~~ to stay within the range about the final value.

(6) (a)



Optical encoder (Incremental type)

It consists of a disk marked with alternating transparent & opaque stripes aligned radially. A photo-transmitter is located on one side of the disk & a photo receiver is on the other side.

As the disk rotates, the light beam is alternately completed & broken. The output from the photo receiver is a pulse train whose frequency is proportional to the speed of the rotation of the disk.

Generally two sets of photo transmitters & receivers aligned 90° out of phase. This phasing provides the information of if the encoder is rotating in clockwise direction or anti-clockwise direction. By counting the pulses & by adding or subtracting it is possible to use encoder to provide position information with respect to the starting location.

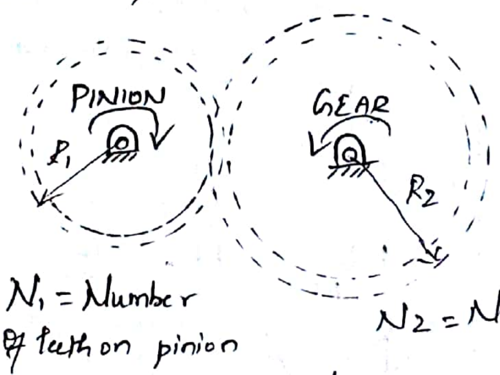
6) b) Power transmission systems perform two functions

(i) Transmit power at a distance

(ii) Act as a power transformer

Gears are the most common type of power transmission systems in robots. It is used to transmit rotary motion from one shaft to another. This transfer may be between parallel shaft, intersecting shafts or skewed shafts.

The simplest type of gears used are spur gears



Spur gear train

The driving gear is known as pinion & the other gear is driven gear. Since the number of teeth on pinion gear is less than the driven gear this gear train acts like speed reducer.

The gear ratio is given by $n = \frac{N_1}{N_2}$

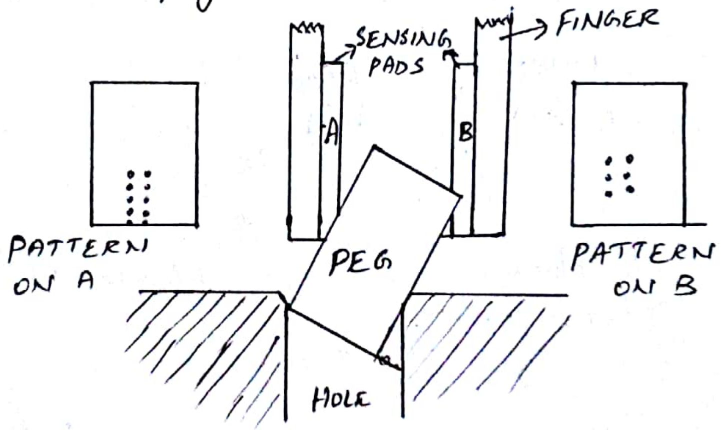
& the speed of the output w.r.t input is $\omega_o = n\omega_{in}$

ω_o = output speed ω_{in} = input speed.

7) Tactice array sensor is a special type of force sensor composed of an array of force sensing elements.
These type of devices is combined with pattern recognition to describe number of characteristics like
ⓐ presence of an object ⓑ Contact object's area, location shape & orentation, ⓒ the pressure distribution ⓓ Force magnitude etc.

Example :- Use of a tactile array sensor is to measure the force & moments being applied to an object by the robot. A typical application of this capability is the case of a robot inserting a peg into a hole.

Suppose peg misses the hole slightly creating a binding action between the peg & the hole.



Possible binding action in an insertion task

As the peg tilts as shown in figure we can see the pattern generated ~~on~~ because of the contact made on the array sensors placed on the sensing pads on both A & B.