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25th BATCH

COMPUTER AND COMMUNICATION ENGINEERING

International Islamic University Chittagong

COURSE CODE: CCE-4727

COURSE TITLE: Robotics and Automation

COURSE TEACHER:

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External
Computer and Communication Engineering

PdF-1
(Automation)

Introduction

Automation refers to the use of tech without human intervention.

Ex:- Automated car, Robots for specific works in company or else where, personal Assistant Robots that can help.

Automation

Doing tasks without the intervention of human. And these tasks are done by technology such as sensors, AI, etc.

From simple work like turning on the light, to complex work like Operating Plane these all falls in Automation if there is no human intercepting.

Ex:- Automated cars, Smart thermostats, Amazon's Alexa.

Different Types of Robots

Specific Tasks, pet bot, Fire service bot, Entertainment, Day Dangerous Task bots.

Robots in Industry

Robots can work dangerous task with low errors.
Where multiple human needed for a single work.
Robots have efficiency too.

Robots in Everyday Life:

→ Cleaning Robots:
→ Delivery Robots.
→ Personal Assistant Robot.

Difference between Robots & Robotics

→ Robotics is the study of Robot. It is the science behind Robots.
→ Robot is the practical Application of that science. Robotics is the broader field (construction, design, operation). Robotics involve creating machines

Automation & Robotics

→ Often used interchangeably.

→ Automation helps to perform task without the help of human intervention.

→ Robotics works in ~~tool~~ creation. ~~All~~

→ All Robotics use Automation,
Not all Automation involves Robotics.

Ex:- A Conveyor belt moves product is Automation.
A Robot hand assembles product is a Robotics.

BdF-02

Robotics Anatomy & Basic Sensors of Robots

=> The anatomy of robot is concerned with the physical construction of the body, arm & the wrist which are attached with each other.

=> The main components of an industrial robot are manipulators, End effectors, Feedback devices, Controllers, and Locomotive devices.

The Components of a Robot

(i) Power Source:- provides energy.

(ii) Controller:- Manages robot's movements

(iii) Actuator:- Converts energy from power source into motion

Also, sensors (Allows to receive its environment)

Manipulator (Enables robot to interacts with objects and perform tasks)

End-effector (used for specific purposes)

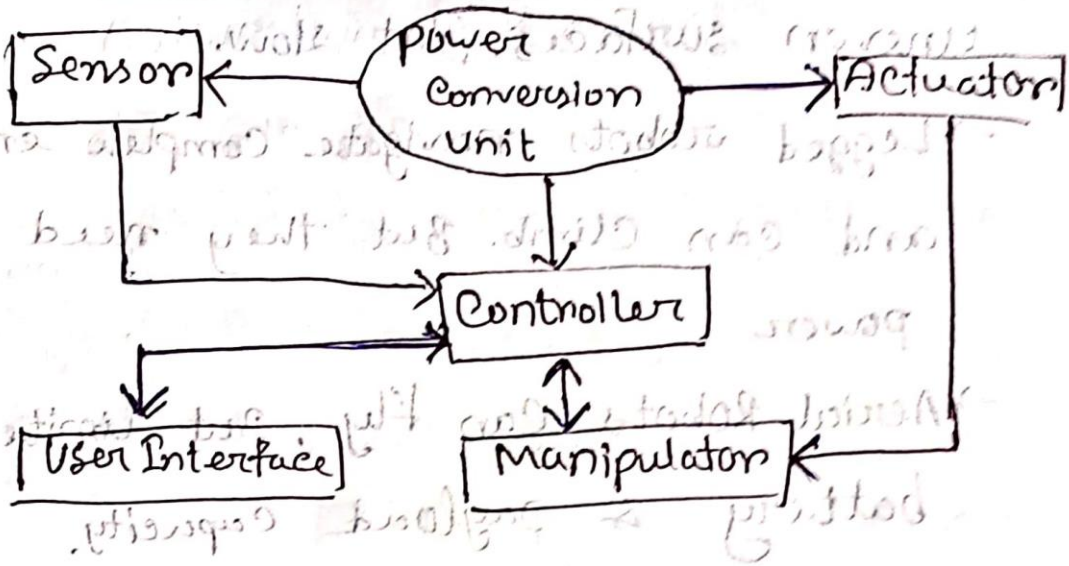


Fig:- The Component of a Robot.

Mechanical Comp. :-

→ Body
→ Joints (Allow robot to move)
→ Actuators.

Electrical Comp

→ sensor
→ controller
→ power sources

Actuators & Sensors

Robot Locomotion

Robots movement. Each with its own advantages & disadvantages.

→ Wheeled robots are simple. But struggle with rough terrain & obstacles.

→ Tracked robots have better traction. & handle

uneven surfaces. But slow.

→ Legged robots navigate complex environments and can climb. But they need more power

→ Aerial Robots can fly. But limited for battery & payload capacity.

And to achieve this we need diff. types of components.

Robot Manipulation

One of the key areas of dev. has been in robot is manipulation. This involves the use of various tools & mechanisms, (Grippers, End-effectors, & manipulators

Gripper :- Designed to hold objects & to do specific jobs.

End-effector :- Specialized tools that are joined with the body.

Manipulators :- Multi-joined arms.

Basic Structure Of Robots

→ Robots (Mechanical & virtual device)

→ can be guided by external control or operate using AI.

→ Can be found in manufacturing, healthcare, exploration, transportation & entertainment industries.

Classification Of Robots (types of Robot)

→ Industrial Robots:- Manufacturing, assembly, welding, painting etc

→ Service Robots:- Healthcare & Customer Service.

→ Mobile Robots:- Exploration, transportation & navigation tasks.

→ Collaborative Robots (cobots):- Intend to work with human

→ Educational Robot :- Teaching (Educational purpose)

→ Entertainment Robot
→ Military Robot
→ Space Robot
→ Humanoid Robot
→ Agricultural Robot

Robot Kinematics:-

→ Refers to study of the Robot's motion without considering forces.

→ (i) Forward Kinematics:- Calculating the end-effector's position based on joint angles.

(ii) Inverse Kinematics:- Finding joint angles for a ~~desig~~ desired end-effector position.

Robot Dynamics

→ Deals with forces

→ Torques that affect a robot's motion.

→ understanding dynamics is crucial for accurate & safe robot operations.

Degrees of Freedom (DOF)

→ The degrees of freedom are the number of independent movements a robot can perform.

→ DOF allows for increased flexibility & complexity.

Robot programming

1] Teaching pendant:- Manually moves the desired motions

2] Offline programming:- Simulation s/w.

3] Scripting:- C++ , Python.

4] AI:- Training robots using ML.

Safety Considerations

→ Environment, Human

→ Physical barriers to prevent collisions.

→ Compliance with safety standards & regulations.

→ Regular maintenance & inspections.

→

Pdf - 3

(Classification Along with Structure & path system of Robots)

Essential elements for Industrial Robots:-

(1) Mechanical Elements

(2) Electronic Circuits

(3) S/W

Types of Industrial Robots and Their Features

(1) Cartesian Coordinate Robots:- They can only move in straight line.

(2) Articulated Robots:- Have great freedom of movements.

(3) Dual-arm Robots:- Can hold boxes from both sides.

(4) SCARA Robots:- Arms operated horizontally widely used in assembly processes.

(5) Parallel Robots:- When they have a low weight capacity they are highly suited to high speed

Lecture-3

(A&RH PDF)

(Automation Technologies for Manufacturing Systems)

Basic type of Automation : (3 types)

1] Fixed Automation :-

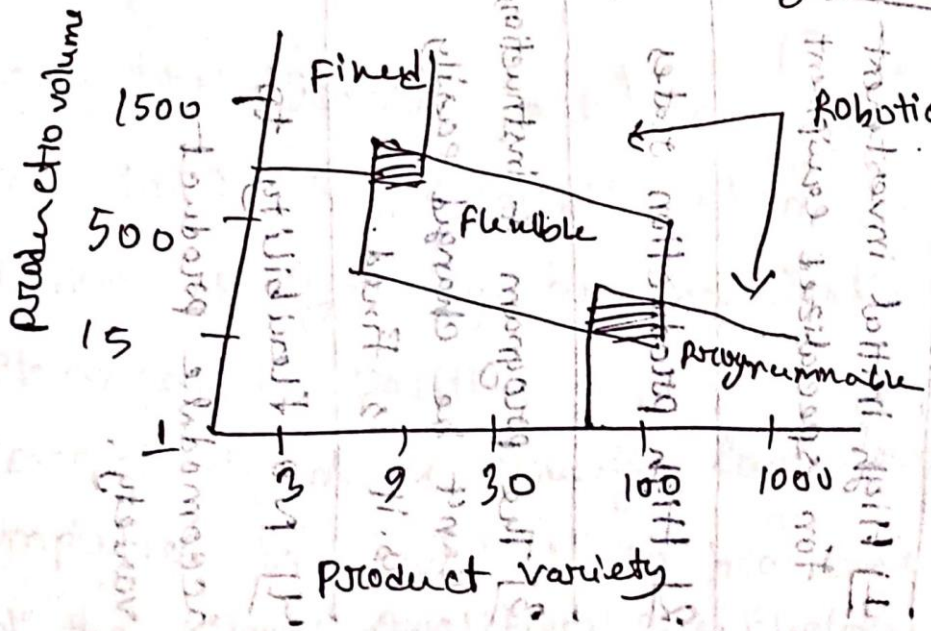
→ Assembly & processing steps are fixed by the equipment configuration.

2] Programmable Automation :-

→ Designed to change the program of instructions to Allow production of different parts or products.

3] Flexible Automation :-

⇒ The automation in which virtually no production time lost. For setup changes or reprogrammed.



Difference between Fixed, programmable, Flexible

Fixed	programmable	Flexible
1] High initial investment for specialized equipment	1] High investment in general purpose equipment which can be reprogrammed	1] High Engineer investment for custom-engineered equipment.
2] High production rates	2] Lower production rates than fixed automation	2] Medium production rates.
3] The program & instructions can't be changed easily as it is fixed.	3] Have ability to change program with the variety.	3] Capable to produce a mixture of different parts or products without losing production time.
4] No-flexibility to accomodate product variety.	4] Suited to batch production.	4] Continuous production of different part or product style

Sensor & Actuator

Sensor:- The device that converts a physical stimulus or variable of interest into an electrical voltage for the purpose of measuring the variable.

2 types:-

(i) **Analog Sensor:-** It measures a continuous analog variable and converts it into a continuous signal.

(ii) **Discrete Sensor:-**

It produces a signal that can have only a limited number of values.

Actuator: Device that converts a control signal into a physical action.

→ Action is typically mechanical. Such as a change in position.

→ Control signal is usually low level. So an amplifier is needed to increase the power of the signal. Amplifiers are Electrical, Hydraulic, Pneumatic

Hydraulic System

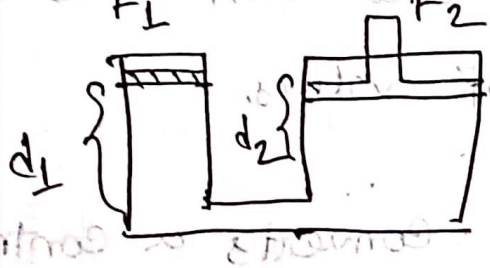
→ works on the principle of pascal's Law

Pascal's Law:-

~~Pressure exerted by a confined fluid acts~~ pressure applied anywhere in confined (आवद्ध) incompressible (असंपीड्य) fluid is transmitted equally in all direction throughout the fluid.

Pressure $P = F/A$

F = Force (lb)
A = Area (in^2)
P = pressure ($lb\ in^{-2}$)



Output Force

$F_2 = \frac{A_2}{A_1} \cdot F_1$

Multiplication of force

$P_1 = \frac{F_1}{A_1}$ $P_2 = \frac{F_2}{A_2}$

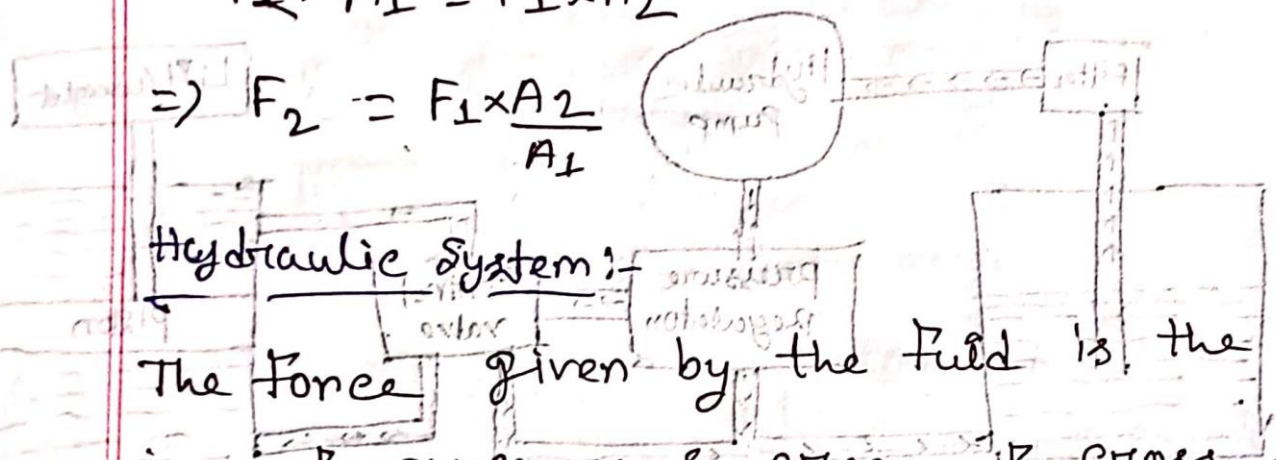
$\Rightarrow F_1 d_1 = F_2 d_2$

$\frac{F_1}{F_2} = \frac{d_2}{d_1} = \frac{A_2}{A_1} \times d_2$

বা২৫ঃ,

$$F_2 \times A_1 = F_1 \times A_2$$

$$\Rightarrow F_2 = F_1 \times \frac{A_2}{A_1}$$



Hydraulic System :-

The force given by the fluid is the multiplication of pressure & area of cross section.

As pressure is same in all the direction the smaller piston will feel smaller force & a large piston will feel larger force. Therefore, a large force can be generated by small piston.

=> There are couple of parts in it

Storage tank, Filter, Hydraulic pump, pressure regulator, Control valve, Hydraulic cylinder, piston & leak proof.

Schematic Hydraulic System

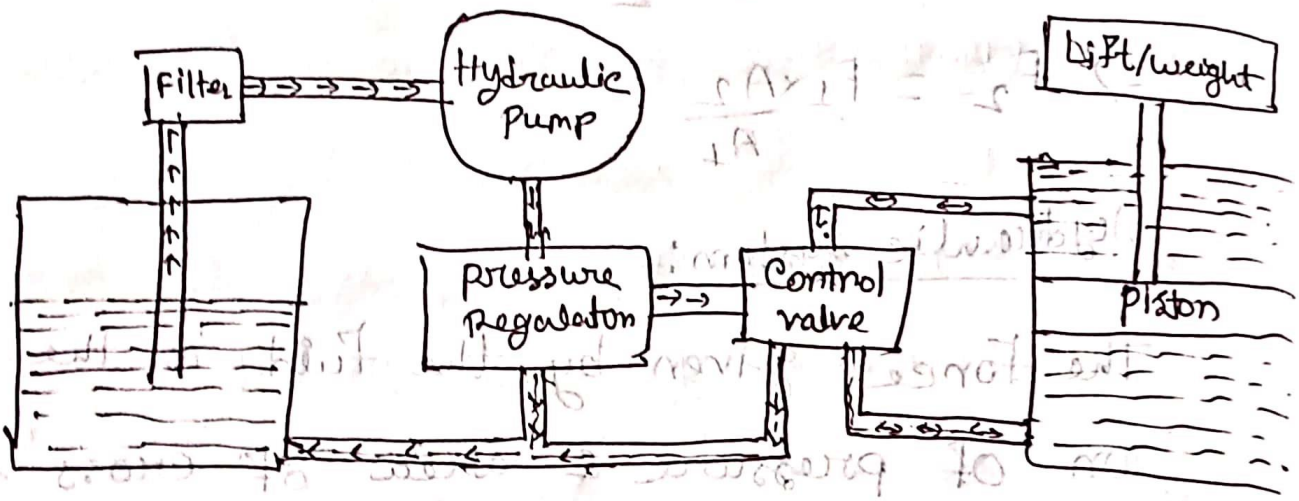


Fig → Schematic Hydraulic System

→ Fluid Tank	→ Pressure Regulator
→ Filter,	→ Control valve
→ Hydraulic Pump	→ cylinder with a movable piston.

Application of Hydraulic Systems

→ To Control larger forces

Factories :-

→ Plastic processing

→ Crushes

→ Steel making

→ Machine tool & Industries.

→ R & D equipment
→ Robotic Systems
→ Paper Industries
→ Machine tool Industries
→ Loaders,

Mobile Hydraulics

→ Tractor
→ Irrigation System
→ Earthmoving objects
→ Commercial vehicles
→ Rail equipment
→ Building & Construction Machinaries.

Automobiles :-

→ Brakes,
→ Shock absorber
→ Steering System
→ Wind Shield.
→ Fishing boats.

Advantages of Hydraulic system

→ uses incompressible (অসংকোচনীয়) fluid results in higher efficiency

→ Gives consistent power output

→ Employ high density incompressible fluid.

→ possibility of leakage is less

→ Maintenance cost is less

→ perform well in hot environment conditions.

Fundamental Law of Hydraulic pressure

→ Force applied in an enclosed area liquid, a pressure is produced.

pressure is the distribution of a given force over a certain area.

pressure, $P = F/A$

Force in Newtons (N)

Area is in square meters (m^2)

1 pascal (Pa) = $1\ N/m^2$

1 bar = 100,000 Pa = 10^5 Pa

1 bar = 100,000.0 Pa = 10^6 Pa (1 Mega pascals)

Math:-

A cylinder is supplied with 100 bar pressure; Its effective piston surface is equal to 700 mm^2. Find the max force

we know,

$F = PA$

$= (1.0000000 \times 0.0007)\ N$

$= 7,000\ N$

1 bar = 1000,00 Pa

100 bar = 1000,000,00 Pa

$= P$

$A = 700/1000000$

$= 0.0007\ m^2$

Pascal's law & implementation

(prev.)

Implementation:-

(i) Hydraulic System

(ii) Pneumatic System.

Control valves

In order to control output of Hydraulic system different types of valves are used.

There are three types of valves employed in Hydraulic Systems:-

→ Directional control valves

→ Flow control valves

→ pressure control valves.

There are many valves which are classified based on their characteristics & works:-

① Types of construction:-

→ poppet valves

→ Spool valves.

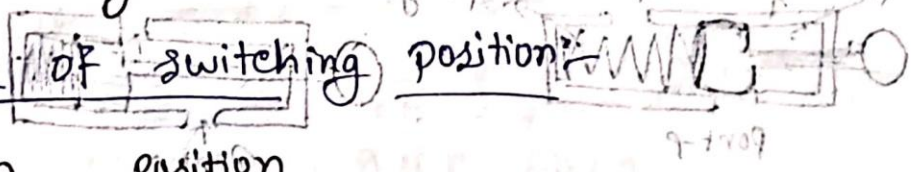
② Number of ports:-

→ Two way valves

→ Three way valves

→ Four way valves.

Number of switching position:-



→ Two position

→ Three position

Actuating Mechanism:-

→ Mechanical Actuation

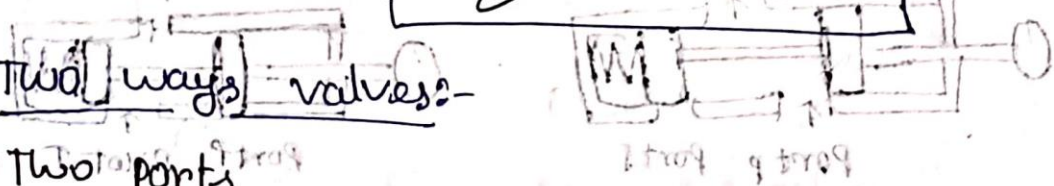
→ Solenoid Actuation

→ Hydraulic Actuation

→ Pneumatic Actuation

→ Indirect Actuation.

Number of ports

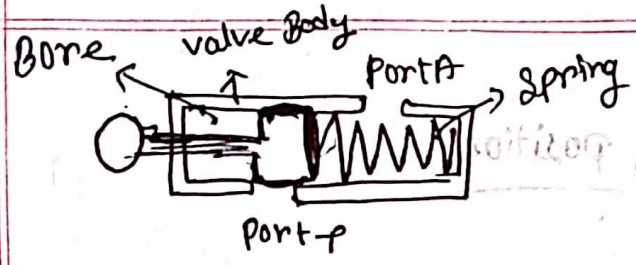


* Two ways valves:-

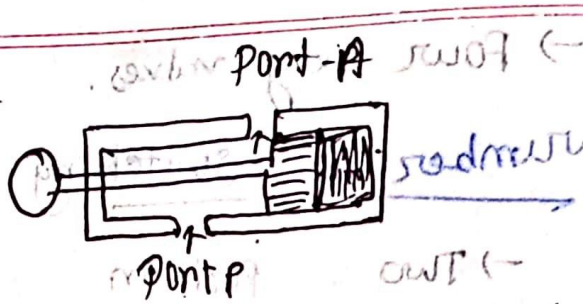
→ Two ports

→ Valves are known as Off/On valves. Cause they allow fluid flow only in direction.

→ When actuating force is not applied in the right the port P is not connected with port A. Therefore, the actuation does not take place.



(Not connected)



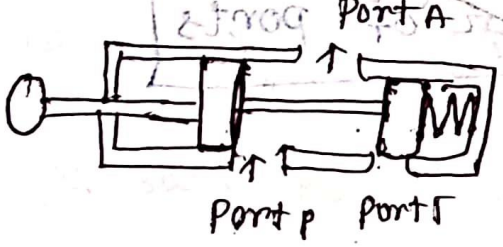
(Port P is Connected with A)

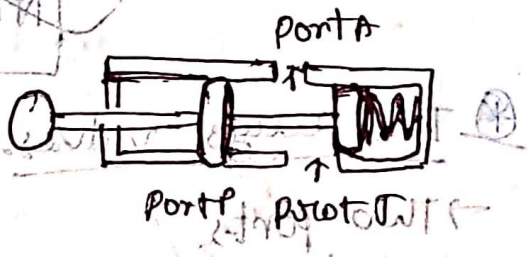
Three way valves:

→ Three ports

→ ~~It is the valve where~~

→ If the pressure port pressurizes one port & exhausts another one. Then it is three way valves.





Four way valves:

→ used for cylinders & fluid motors.

→ there are three ports & two working ports. The primary function is to pressurize & exhaust two working ports A & B alternatively.

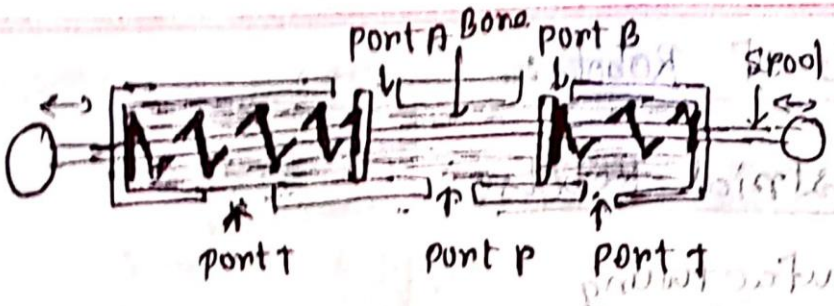
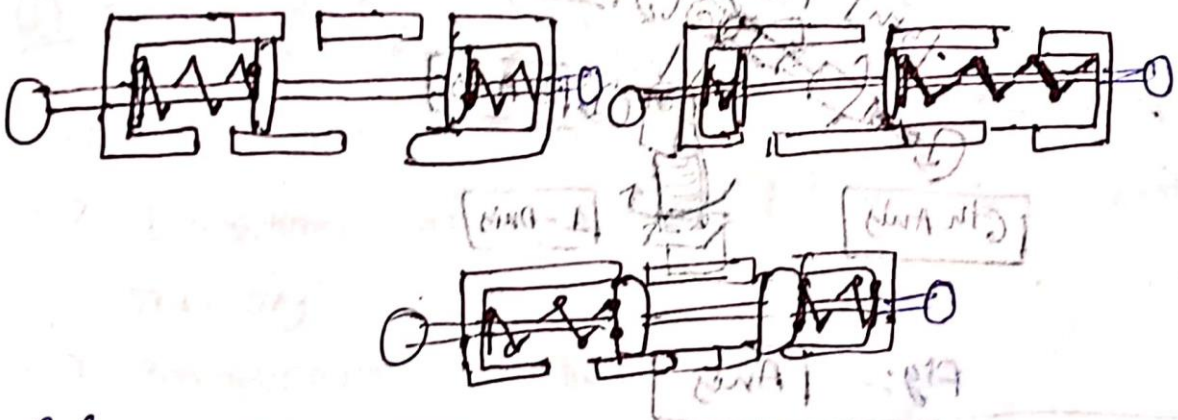


Fig:- Four way valves.

3/4 ways:-

→ Used in double acting cylinders to performance advance hold & return operation to the piston.

→ Switching positions.



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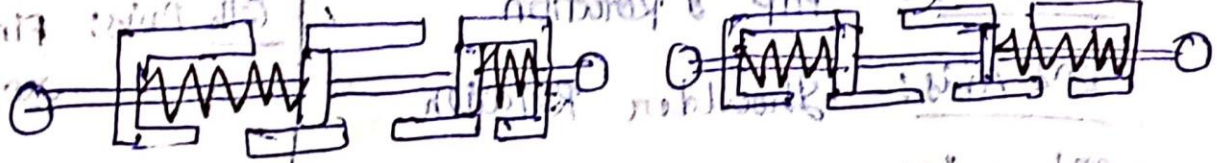

Types of Robots:-

1] Industrial Robots:-

→ Manufacturing
→ Welding
→ Automotive

2] Mo

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Axis Draw:-

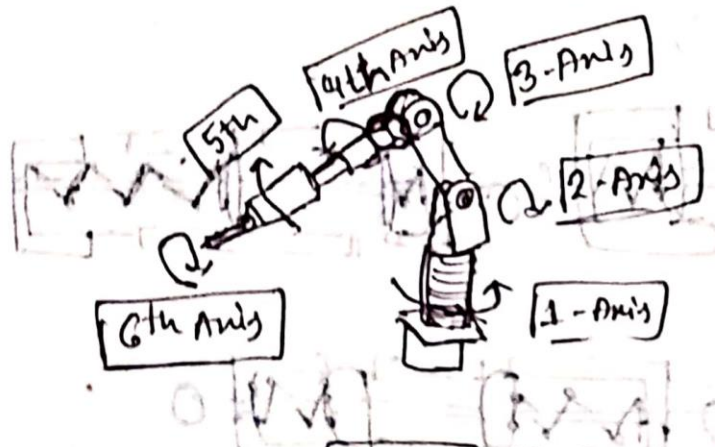

Fig:- Axis

1st Axis:- Hip Rotation
2nd Axis:- Shoulder Rotation
3rd Axis:- Elbow joint movement
4th Axis:- Wrist rotation
5th Axis:- Wrist Bending

6th Axis:- Fingertip rotation.

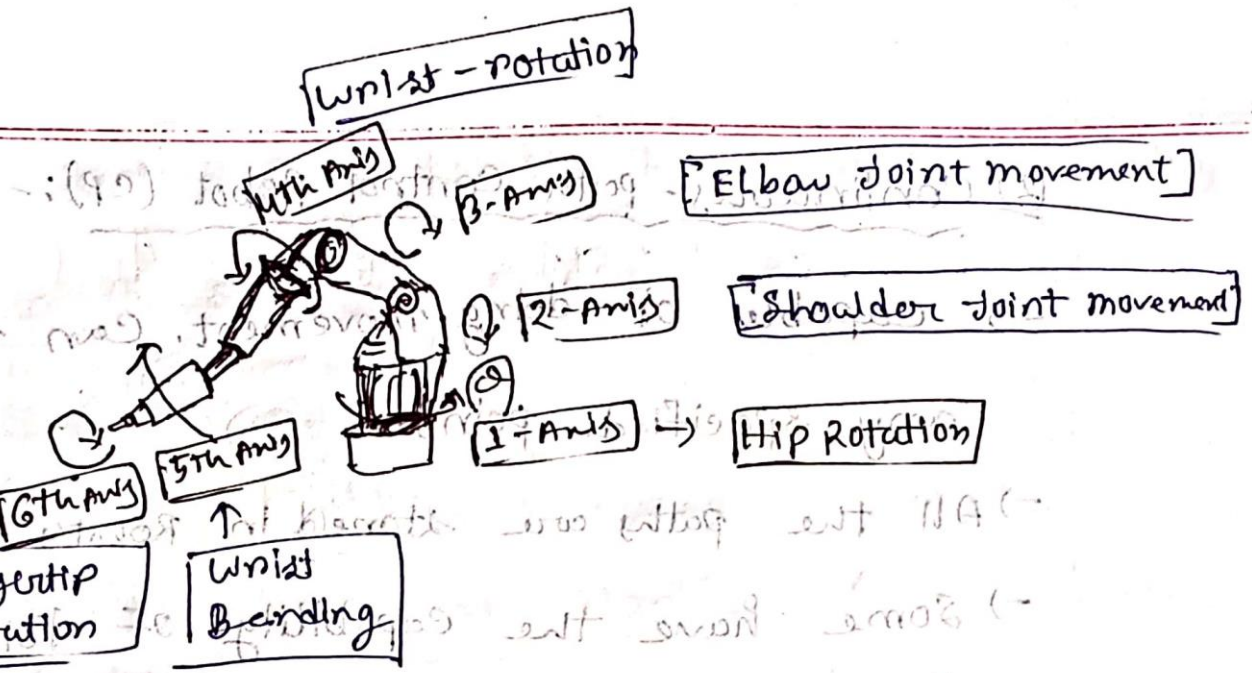

Fig:- Axis Drawing Robot

Four Type of Robot Control

(1) Point - to-Point control robot :-

→ Move from one point to another point.
→ Locations are recorded in the control memory.
→ Component insertion
→ Welding
→ Hole drilling
→ Machine Loading & Unloading
→ Assembly operations.

(2) Continuous-path Control Robot (CP):-

→ Capable of doing movement. Can stop at any specified point.

→ All the paths are stored in Robot's memory.

→ Some have the capability of following the smooth curve path.

Examples:-

→ Spray painting

→ Finishing

→ gluing

→ Arc welding.

(3) Controlled Path Robot:-

→ This type of robot can move into any direction with a perfect accuracy.

→ These can move in a straigh line, circle, curve etc ways.

→ Only the start & finish point needs to be stored in the memory.

→ All control path robot's have servo capability.

4] Stop to stops-

→ Open loop system.

→ position & velocity unknown to controller.

→ On/off commands stored as valve states.

→ End travel set by mechanical.

4] Difference between Robots & Robotics :-

Robots	Robotics
① Physical machines or devices to perform tasks	① Broader field that involves the study, design etc.
② The physical body that fullfil tasks.	② Focus on the domain of research, study.
③ Robots have physical components, sensors, actuators & often include some level of AI for decision making.	③ It includes understanding machines, programming, control systems.

Robot	Robotics
① used in industries for tasks.	① uses areas like Kinematics, control theory, Computer vision etc.
② Can perform various works.	② Applied in making different Robots.
③ Physical thing	③ Theoratical thing.
④ Example:- (i) Industrial Robot arms (ii) Humanoid Robots (iii) Drones.	④ Example:- (i) Algorithm for Robot (ii) Sensors (iii) ~~Sensors~~ S/w for Robot Development

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Pneumatic System:-

Deals with the study of behaviour & application of compressed air.

Air is available & can be exhausted into the air.

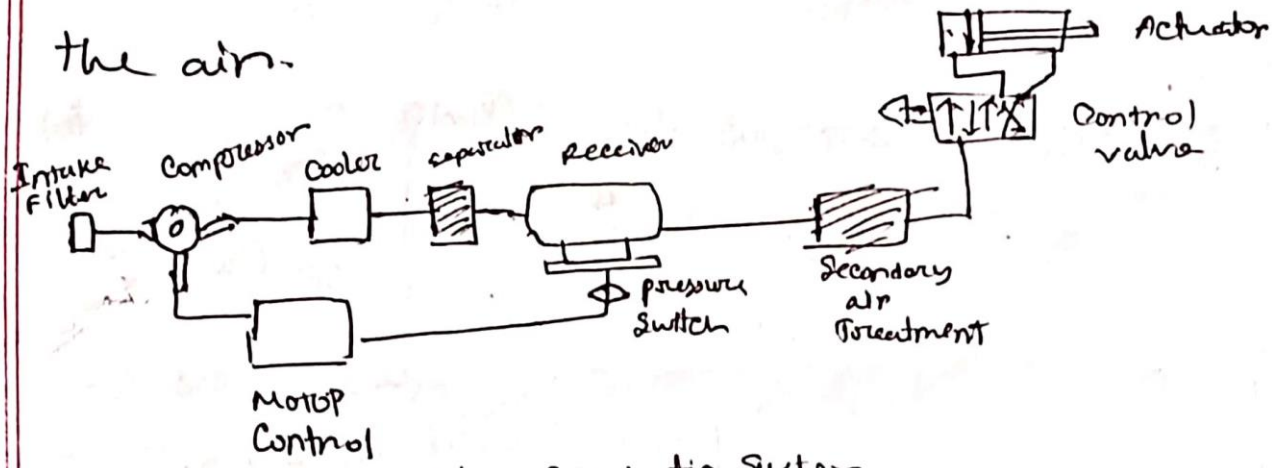


Fig:- Pneumatic System

Air Filter:- Use to filter contamination from air

Compressor:- Compress air

Air cooler:- Use to reduce temperature of compressed air

~~Seperator:-~~

Dryer:- water vapor or moisture in the air is separated.

Control valves:- Used to regulate, control & monitor of direction flow, pressure etc.

Air Actuator:- Cylinder & motors are used

Electric Motor:- Transform Electrical into mechanical

Receiver Tank:- Compressed air coming from the compressor is stored.

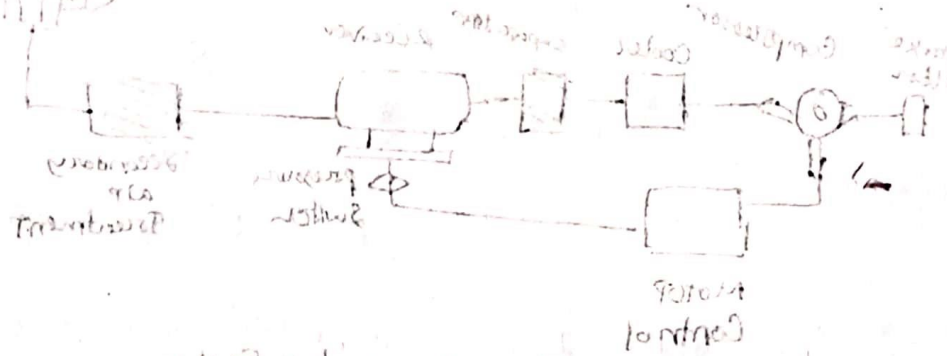
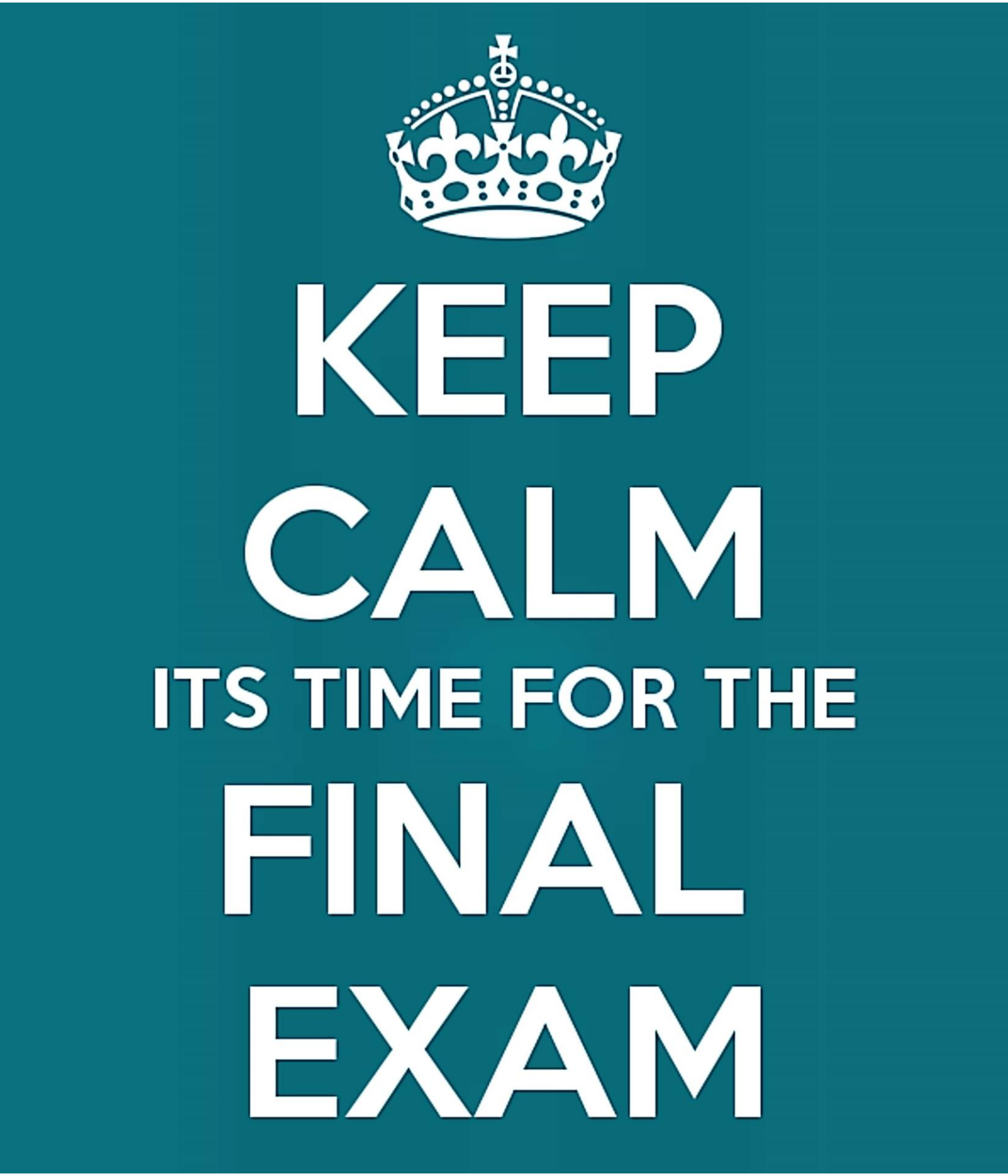


Fig:- pneumatic system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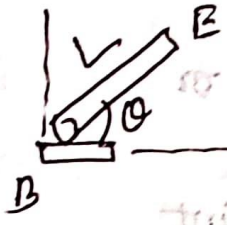
2 Kinematic Math:-

2D Kinematic:-

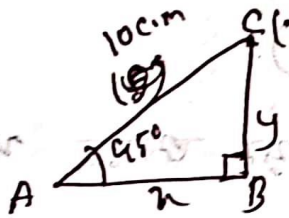


B = Base

L = Link

E = End effector

(*)



Find the position (x,y) using the trigonometry

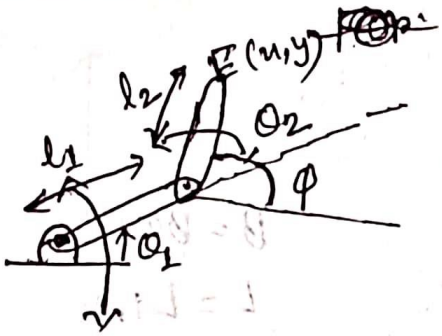
=> we know,

$\cos\theta = x/10$

$\therefore x = \cos\theta * 10 = \cos(45°) * 10 = 7.071$ c.m

$\therefore y = \frac{\sin\theta}{\cos\theta} * 10 = \sin(45°) * 10 = 7.071$ c.m

(*)



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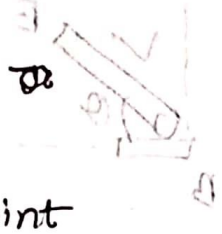


→ Joint space (θ_1, θ_2) হচ্ছে joint

→ World space (Coordinate) (x, y).

Forword kinematics :- θ_1, θ_2 দেওয়া থাকে x, y, ϕ Count করতে হবে। (Also called as Direct kinematics)

Reverse kinematics :- x, y দেওয়া থাকে θ_1, θ_2 বের করতে হবে। (Inverse kinematics)

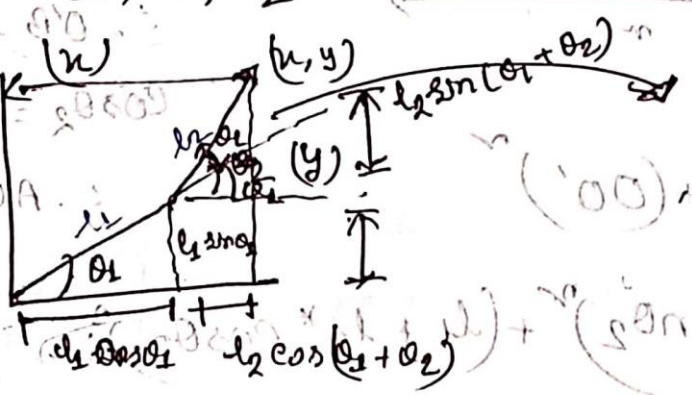
World space : to communicate with external world or other robot.

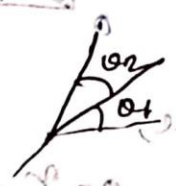
2 DOF Forward Kinematics:-

$x = ?$ $y = ?$ $\varphi = ?$

$\theta_1, \theta_2, l_1, l_2$ দেওয়া আছে।

$C_1 \rightarrow \cos\theta_1$
$S_1 \rightarrow \sin\theta_1$
$C_2 \rightarrow \cos\theta_2$
$S_2 \rightarrow \sin\theta_2$





$\therefore x = l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2)$

$y = l_1(\sin\theta_1) + l_2\sin(\theta_1+\theta_2)$

$\varphi = \theta_1 + \theta_2$

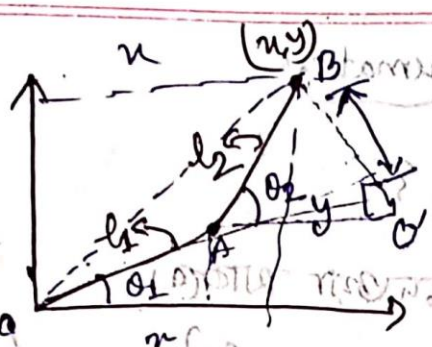
D.
Inverse

2D DOF inverse kinematics:

I know, (x, y), φ, l_1 & l_2

Don't know $\rightarrow \theta_1$ & θ_2

Solve: ① will square both x & y



$x^2+y^2 = OB^2$

$\sin\theta_2 = \frac{O'B}{l_2}$

$\therefore O'B = l_2 * \sin\theta_2$

$\cos\theta_2 = \frac{AO'}{l_2}$

$\therefore AO' = l_2 * \cos\theta_2$

Here,

$OB^2 = OB^2 + (OO')^2$

$x^2+y^2 = (l_2\sin\theta_2)^2 + (l_1 + l_2 * \cos\theta_2)^2$

$x^2+y^2 = l_2^2 s_2^2 + l_1^2 + 2 l_1 \cdot l_2 c_2 + l_2^2 c_2^2$

$2 l_1 l_2 c_2 = x^2+y^2-l_1^2-l_2^2$

$c_2 = \frac{x^2+y^2-l_1^2-l_2^2}{2 l_1 l_2} = \cos\theta_2$

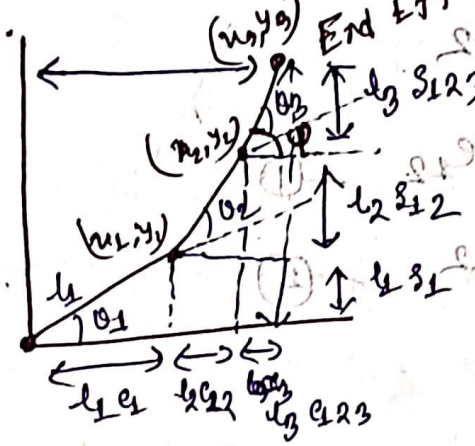
$\therefore \theta_2 = \cos^{-1}\left(\frac{x^2+y^2-l_1^2-l_2^2}{2 l_1 \cdot l_2}\right)$

$\theta_1 = \phi - \theta_2$

Inverse Kinematic may not have Unique Solution.

3 DOF for FK & IK

Forward:-



$$x_3 = l_1 c_1 + l_2 c_{12} + l_3 c_{123}$$

$$y_3 = l_1 s_1 + l_2 s_{12} + l_3 s_{123}$$

$$\phi = \theta_1 + \theta_2 + \theta_3 \quad (123)$$

Inverse:-

$x_3, y_3, l_1, l_2, l_3, \phi$ ज्ञात

$\theta_1\ \theta_1\ \theta_3 = ?$

(1) $x_2 = x_3 - l_3 \cos\varphi$ $\quad \varphi = \theta_1 + \theta_2 + \theta_3$

$y_2 = y_3 - l_3 \sin\varphi$

$\cos\theta_2 = \dfrac{x_2^2 + y_2^2 - l_1^2 - l_2^2}{2 l_1 l_2}$

or, $x_2 = l_1 c_1 + l_2 c_{12}$ — (i)

& $y_2 = l_1 s_1 + l_2 s_{12}$ — (2)

From (1)

$x_2 = c_1 (l_1 + l_2 c_2) - s_1 (l_2 s_2)$ — (i)

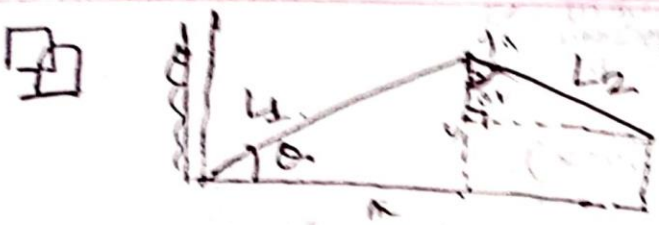
$y_2 = c_1 (l_2 s_2) + s_1 (l_1 + l_2 c_2)$ — (ii)

$c_1 = \dfrac{(l_1 + l_2 c_2) x_2 + l_2 s_2 y_2}{x_2^2 + y_2^2}$

$s_1 = \dfrac{(l_1 + l_2 \cdot c_2) \cdot y_2 - l_2 s_2 \cdot x_2}{x^2 + y_2^2}$

$\tan\theta_1 = \dfrac{s_1}{c_1} \Rightarrow \theta_1 = \tan^{-1}\left(\dfrac{s_1}{c_1}\right)$

$\theta_3 = \varphi - (\theta_1 + \theta_2)$



$\sin\theta = y/L_1$

$y = L_1 \cdot \sin\theta$

$\cos\theta = x/L_1$

$x = L_1 \times \cos\theta$

Arduino

→ Open-source platform for electronic platform.

→ Physical programmable board.

→ uses IDE to do coding part

→ Arduino does not need a seperate piece of hardware.

→ uses simplified version of C++.

→ Arduino can interact with LED, motors, speakers, GPU units, cameras, the internet, even with smart phone.

→ Arduino can be used as a brain behind almost any electronic project.

Arduino UNO Mega

(i) Power: (USB / Barrel Jack):-

→ Needs a way to connect with computer. UNO can be powered from them. So, ~~Using~~ USB & a barrel jack is are present in the arduino. for that

→ USB Connection is ~~the reason~~ used for load code onto the arduino.

→ Use not more than 20 volts on else it might overpower. Recommended 6 & 12 v.

(ii) GND:- There are several gnd ~~points~~ pins.

(iii) 5(v) & 3.3(v):- 5(v) pin gives 5 v power
3.3 v pin gives 3.3 v power

(iv) Analog :- (A0 to A5) :- This pin reads signal from Analog sensor & convert into digital value.

(v) Digital :- Digital pins (0 to 13) on the UNO. Can be used digital input or output.

(vi) PWM: ~~PINS~~ Digital pins (3, 5, 6, 9, 10 & 11) these pins act as normal digital pins, but can also be used as Pulse-width Modulation.

(vii) AREF:- Stands for Analog reference. It is used sometimes as an external reference voltage (between 0 to 5 volts).

(viii) Reset Button:- Arduino has a reset button. Pushing it will temporarily connect the reset pin to ground & restart any code.

(ix) Power LED Indicator:- There's a tiny LED next to word "ON"

(x) Tx Rx LEDs:- Rx = Receive, Tx = Transmit

(xi) Main IC:- IC is ~~is~~ From ATMEL company

(xii) Voltage Regulator:-

Lilypad: → Flexible
→ Washable
→ Have input, output, power & sensor.

Red Board: → Using USB-mini-B cable using Arduino cable
→ Will work on Window 8
→ More stable due to USB/FTDI
→ Power 7 to 15V DC

Mega:
→ UNO's Big bro
→ 54 digital input/output pin
→ 14 can be used as PWM
→ 16 Analog
→ 1 USB connection
→ 1 Power
→ 1 Reset Button
→ Simply connect with computer with USB.
→ AC to DC adapter / battery

Operating System (OS)

Rasberry supports various OS. Mainly based on Linux & windows. All of them are found on the website.

(1) Rasbian:- Official OS of Rasberry Pi.

→ Customized based on Debian GNU/LINUX
→ Can run on all version of Rasberry.
→ Combine, easy to use, stable operation, meet various Application Needs.
⇒ Strongly recommended OS should use for this.
→

(2) Windows 10 IOT core:-

→ OS made by MS for IOT
→ Also known as Windows 10 IOT OS.
→ Run on the Rasberry Pi of type 2B or above.

There are also Ubuntu MATE, OSMC, LibreELEC, PiNet, RISC OS.

GPIO

→ Powerful feature of Raspberry Pi

→ General purpose Input & Output → GPIO

→ 40 pin GPIO header is found on all Raspberry Pi board.

(i) Voltages :- Two 5V pins & two 3V3 pins are present on the board.

(ii) Outputs :- output pin can be set to high (3V3) or low.

(iii) Inputs :- With internal pull-up or pull-down resistors it is made easier. Pins GPIO2 & GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software.

→ PWM (S/W in all pins
→ H/W GPIO12, 13, 18, 19)

SPI: **SPI0:-** MOSI (GPIO 10)
MISO (GPIO 11)
CE0 (08)
CE1 (07)

I2C:

Data:- (GPIO2) ; Clock (GPIO3)

EEPROM Data:- (GPIO0); EEPROM clock (GPIO1)

Serial

Tx (GPIO14); Rx (GPIO15)

⇒ **SDA & SCL:-**

→ Consitute of I2C interface.

→ The R.Pi can control multiple sensors & components through this.

→ Communication can be done through SDA & SCL.

SCLK, MOSI & ~~MOSI~~ MISO:-

→ SPI on the R.Pi consists of SCLK, MOSI, MISO interface.

→ SCLK → Control data
MOSI → Sends Data from R.Pi

MISO → opposite of MOSI

(5) TXD & RXD:-

Used For Communication betn Rx & Tx Pin.

Rasberry pi vs Arduino

Arduino:-

→ Microcontroller:-

→ Purpose:- Control Hardware

→ programming:- Using IDE . C/C++.

→ I/O pins:- Limited I/O pins for Connecting sensors & actuators.

→ Power Consumption:- lower power than Rasberry pi.

→ Real-Time Operation:- Suited for real time operations.

→ Applications:- Robotics, Home Automation etc.

Rasberry Pi:-

Microprocessor:- A single board Computer with a broadcom ARM.

(2) purpose :- Designed to function as a small, low-cost computer capable of running a full operating system.

(3) Programming :- Supports C++, python, Java etc.

(4) I/O pins :- More than Arduino

(5) power :- Higher than Arduino

(6) OS :- Run various os.

(7) Application :- Media, web servers, software Development.

Sensors

Proximity:- It is placed at the end part such as end effector. This is turned on at a specific distance, measured by feet or milimeters.
Also find the presence of human in the work volume so that accident can be reduced.

→ An Infrared (IR) LED transmits a beam of IR light & if it finds an obstacle, the light is simply reflected back which is captured by an IR receiver. Few IR transceivers can also be used for distance measurement.

Ultrasonic Sensors:- This sensor generate high frequency sound waves; The received echo suggests an object interruption.
It is also used for distance measurement.

(c) Tactile Sensors :- Device that specifies the contact between an object & the sensor is called as tactile sensor.

Ex:- Elevator buttons, lamps with dim & brighten.

Can be sorted into two part :-

(a) Touch Sensors :- Sense & detect touching of a sensor & object.

→ Ex:- Micro-switches, limit-switches etc.

→ Can be used as inspection device which has a probe to measure the size of a component.

(b) Force Sensors :- Included for calculating the forces of several functions like the machine loading & unloading, material handling & so on.

There are several technique used here :- Joint Sensing, Robot-wrist force Sensing, Tactile array sensing.

① Methods :- Teaching pendants :-

→ Most popular.

→ 90% Robots are programmed using this.

→ Has changed a lot throughout its lifetime.

→ Modern days have gotten smaller size

→ Moves from point to point using the button & save each position individually.

Advantage :-

→ Traditional Industrial robots makes familiar to technicians.

→ Allow precise positioning, as the robot can be programmed using numerical coordinates.

→ Great for simple movements such as painting in a straight line.