Faculty of Engineering
Department of Electrical-Electronics Engineering

Introduction to Robotics

Homework

DESIGN OF AN INDUSTRIAL ROBOT

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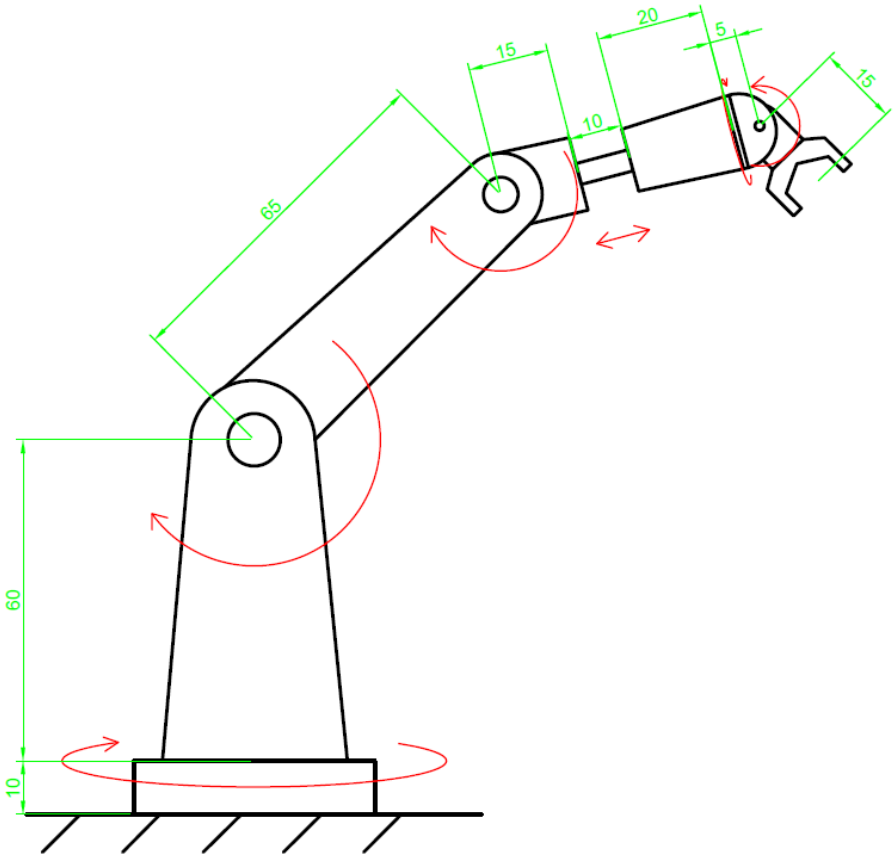
My designed robot is a universal assembly robot for car manufacturing with changeable grabber. Robot is approximately human size with capability of lifting parts up to 30 kg. It is powered with AC servo motors and can reach 360° around itself.

Specification	
Lifting capacity	30 kg
Reach	1300 mm
Height(min/max)	700/2000 mm
Degrees of freedom	6
Mechanical weight with pedestal	500 kg
Repeatability	±0.08 mm
Mounting method	Floor
Drive method	Electric servo motors
Grabber	Pneumatic changeable gripper
Motion range	
J1	360°
J2	245°
J3	270°
J4	0-100 mm
J5	360°
J6	180°
Maximum speed	800 mm/s
Environment	
Ambient temperature	5°C – 45°C
Relative humidity	Max 95%
Noise level	Max 70 dB
Emission	EMC/EMI shielded

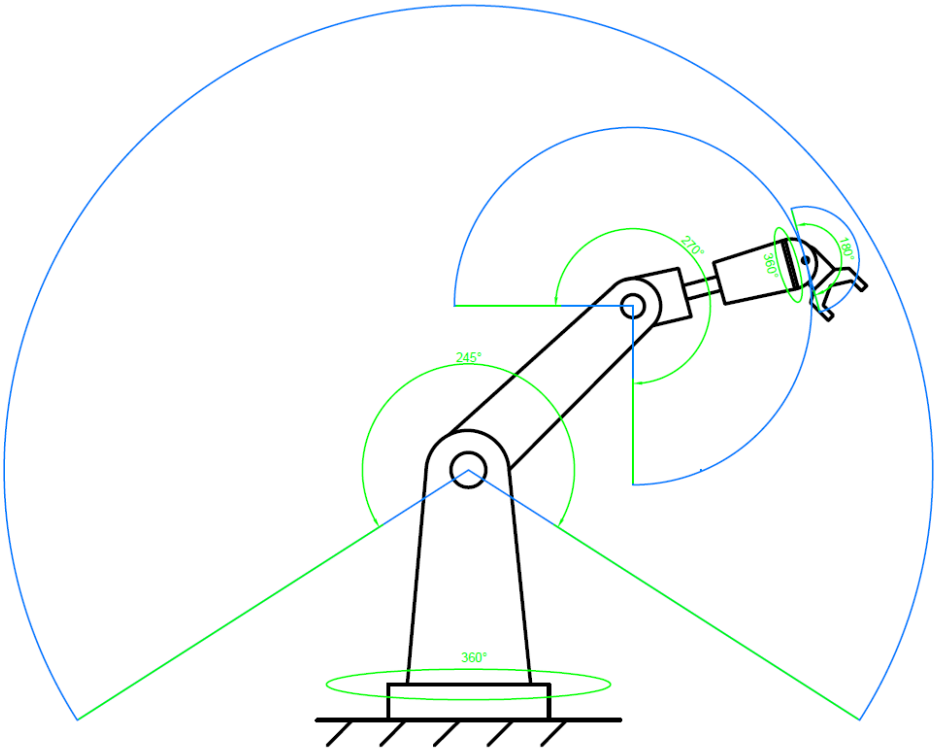
Drawing with dimensions (measurements in cm):



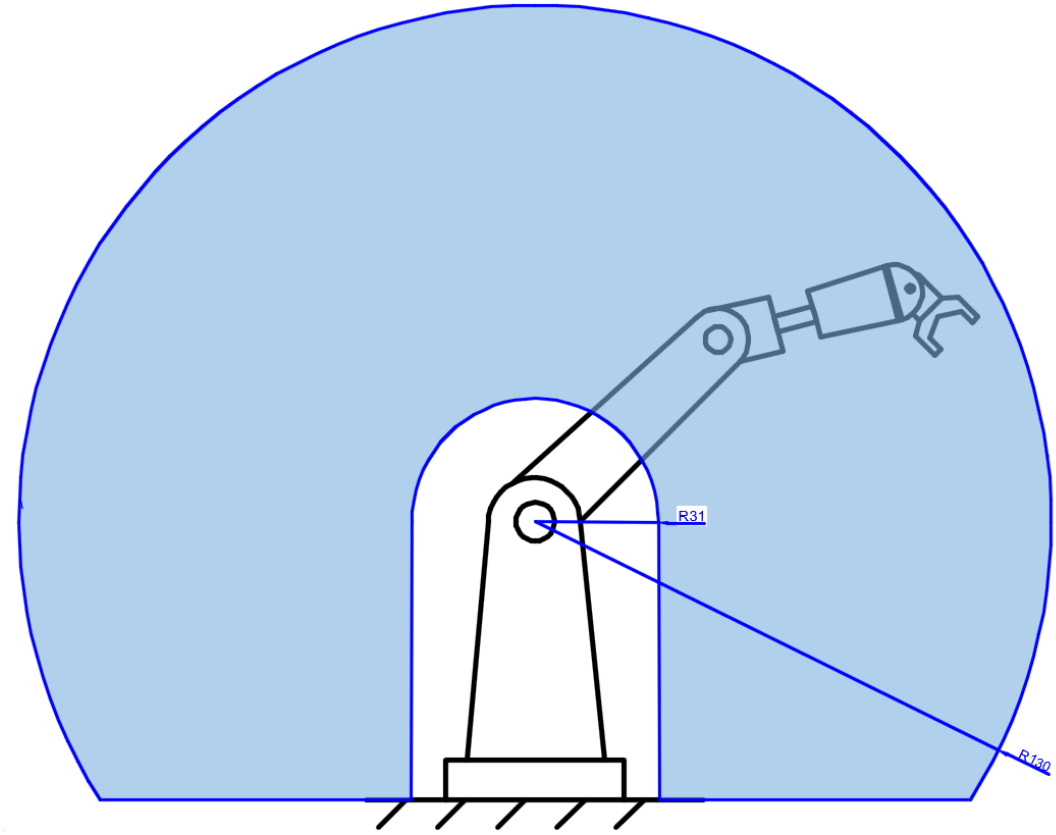
3D model:

Robot has 5 links, 4 kinematic pairs, two of them have 2 degrees of freedom.

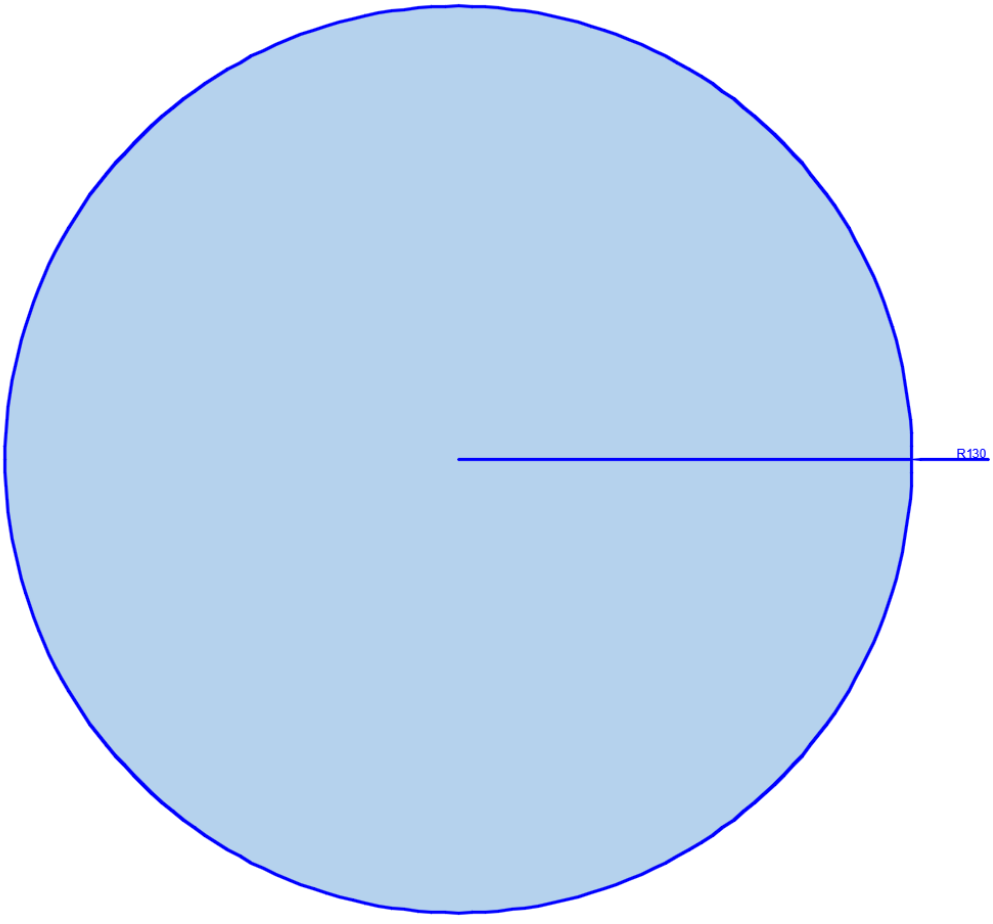
Motion range drawing:



Work envelope is spherical (side view, measurements in cm):

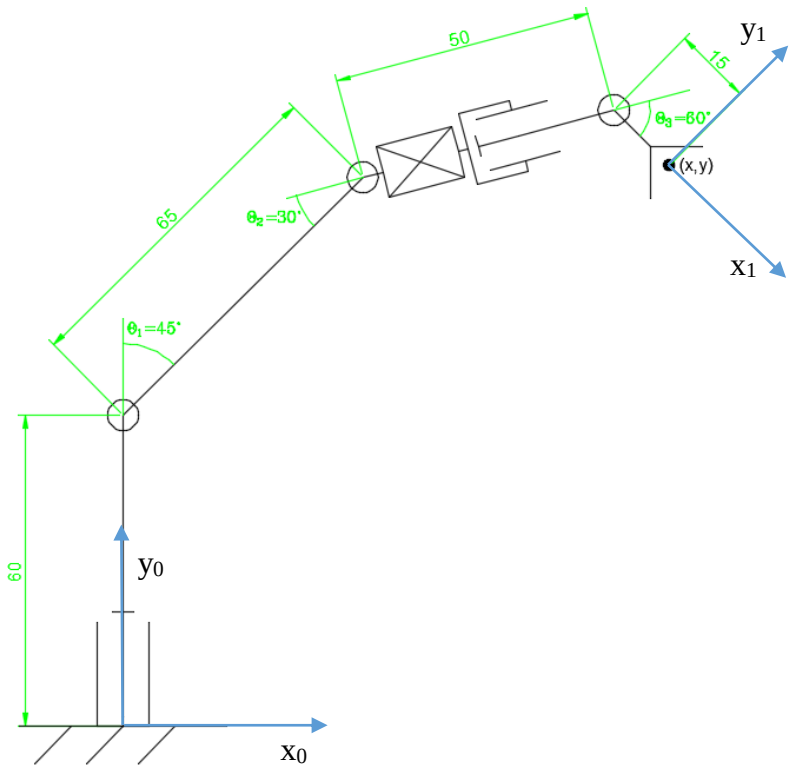


Work envelope (top view):



Part II

Kinematic scheme of the robot:



Length of the links:
$a_1 = 60cm, a_2 = 65cm, a_3 = 50cm, a_4 = 15cm$

Joints‘ angles:
$\theta_1 = 45°, \theta_2 = 30°, \theta_3 = 60°$

Grabber coordinates:
$x = 0 + a_2 \cdot sin\theta_1 + a_3 \cdot \sin(\theta_1 + \theta_2) + a_4 \cdot \sin(\theta_1 + \theta_2 + \theta_3)$
$y = a_1 + a_2 \cdot cos\theta_1 + a_3 \cdot \cos(\theta_1 + \theta_2) + a_4 \cdot \cos(\theta_1 + \theta_2 + \theta_3)$
$x = 65 \cdot sin45° + 50 \cdot \sin(45° + 30°) + 15 \cdot \sin(45° + 30° + 60°) =$
$= 65 \cdot 0{,}707 + 50 \cdot 0{,}966 + 15 \cdot 0{,}707 = 104{,}86$
$y = 60 + 65 \cdot cos45° + 50 \cdot \cos(45° + 30°) + 15 \cdot \cos(45° + 30° + 60°) =$
$= 60 + 65 \cdot 0{,}707 + 50 \cdot 0{,}259 + 15 \cdot (-0{,}707) = 108{,}3$

Orientation of the grabber:
$x_1 = (\cos(\theta_1 + \theta_2 + \theta_3), \sin(\theta_1 + \theta_2 + \theta_3)) = (\cos(135°), \sin(135°)) =$
$= (-0{,}707, 0{,}707)$
$y_1 = (-\sin(\theta_1 + \theta_2 + \theta_3), \cos(\theta_1 + \theta_2 + \theta_3)) = (-\sin(135°), \cos(135°)) =$
$= (-0{,}707, -0{,}707)$

Part III

Physical Specifications

Max Reach:	2000 mm
Degrees of Freedom:	2 (4 per arm)
Body Weight:	70 Kg without pedestal 140 Kg with optional pedestal

Electrical Specifications

Supply Voltage:	120 volts alternating current
Rated Current:	6 amps
Battery Operation:	DC-to-120V AC Inverter (Note: the Baxter robot has an internal PC, which cannot be powered directly off of 24V DC)
Interface:	Standard 120VAC power. Robot power bus and internal PC both have "universal" power supplies and support 90 – 264V AC (47 – 63Hz)
Max Consumption:	6A at 120V AC, 720W max per unit
Max Efficiency:	87% to 92%
Power Supply:	Uses medical-grade DC switching power supply for robot power bus
Tolerance to Sags:	Sags tolerated to 90V. Sustained interruption will require manual power-up
Voltage Flicker:	Holdup time 20mS
Voltage Unbalance:	Only single phase operation

Computer Specifications

Procesor:	4th Gen i7-4700HQ (6MB, 3,4 GHz) Processor w/HD 5000 Graphics
Memory:	8GB, NON-ECC, 1600MHz DDR3
Storage:	256GB SSD