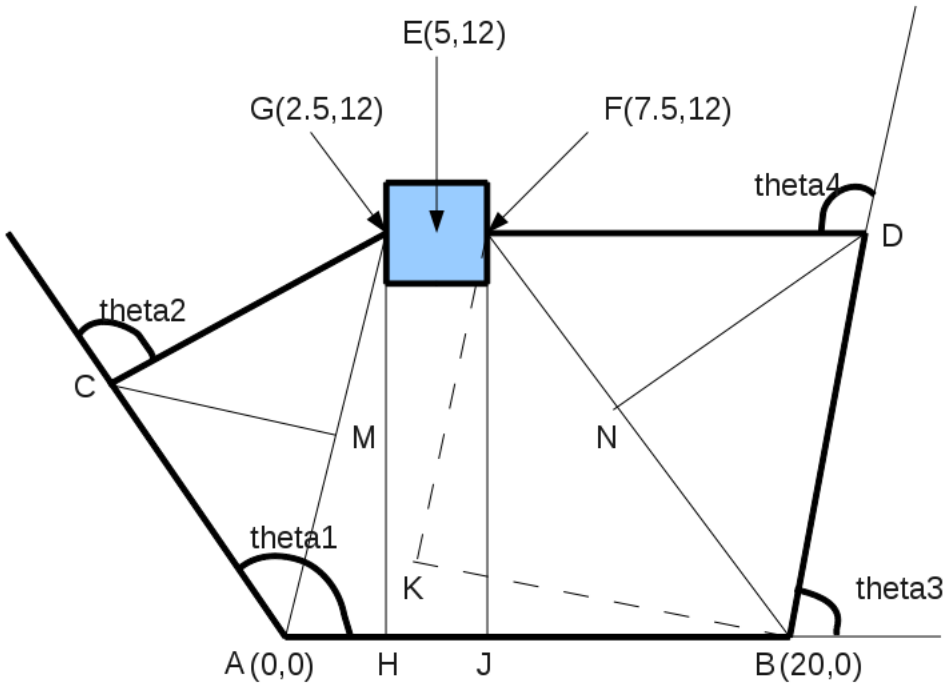
PARTB Question 3

FIGURE



NOTE : FIGURE NOT TO SCALE

ACG and BDF are two robots with L = 15 with AC,CG and BD,DF as its arm.
so,AC = CG = BD = DF = 15 units.
Base distance between robots is 20 units So AB = 20 units.
Consider a square shape box whose center(E) is at (5,12) w.r.t base of left arm on the left (A (0,0))
The two arm tips are holding the box along its horizontal midline at points G (2.5,12) and F(7.5,12)
To find θ_1,θ_2,θ_3,θ_4 of the two robots as shown in figure.
Since length of arms of robot are equal ,so △ACG and △BDF are isosceles.
Drop perpendicular's CM and DN on AG and BF.Being isosceles it will bisect the line segment.
AG = $\sqrt{(12-0)^2+(2.5-0)^2} = \sqrt{150.25}$
BF = $\sqrt{(12-0)^2+(7.5-20)^2} = \sqrt{3000.25}$
In Right △ACM

$cos\angle CAM = \frac{AM}{AC} = \frac{AG/2}{AC} = \frac{AG}{2AC} = \frac{\sqrt{150.25}}{2*15} = 0.408588$

∠CAM = 65.883811 degrees

Similarly In Right △BDN

$cos\angle NBD = \frac{BN}{BD} = \frac{BF/2}{BD} = \frac{BF}{2BD} = \frac{\sqrt{300.25}}{2*15} = 0.5775908$

∠NBD = 54.71873 degrees

Drop prependiculars GH and FJ to AB.
In Right △GAH

$tan\angle GAH = \frac{GH}{AH} = \frac{12}{2.5} = 4.8$

∠GAH = 78.231 degrees

Similarly In Right △FJB

$tan\angle FBJ = \frac{FJ}{BJ} = \frac{12}{12.5}$ (BJ = AB -HJ -AH = 20 - 5 - 2.5=12.5)

∠FBJ = 43.83086 degrees

From the figure it is clear that.
θ_1 = ∠GAH + ∠CAM = 144.11552 degrees
θ_2 = -(2 * ∠CAM) = -131.76762 degrees (Negative because angle is measured in clockwise sense)
(Exterior angle property,and △ACG is isosceles)
θ_3 = 180 - (∠NBD + ∠FBJ) = 81.45041 degrees
θ_4 = 2 * ∠NBD = 109.43746 degrees

Note that ,only this angle configuration is possible,since ∠BFK(= ∠NBD= 54.7187) is more than ∠BFJ(= 90 - ∠FBJ = 46.2)