COMPUTATIONAL MECHANICS AND OBJECT ORIENTED PROGRAMMING

Equilibrium of Rigid Body in 2D

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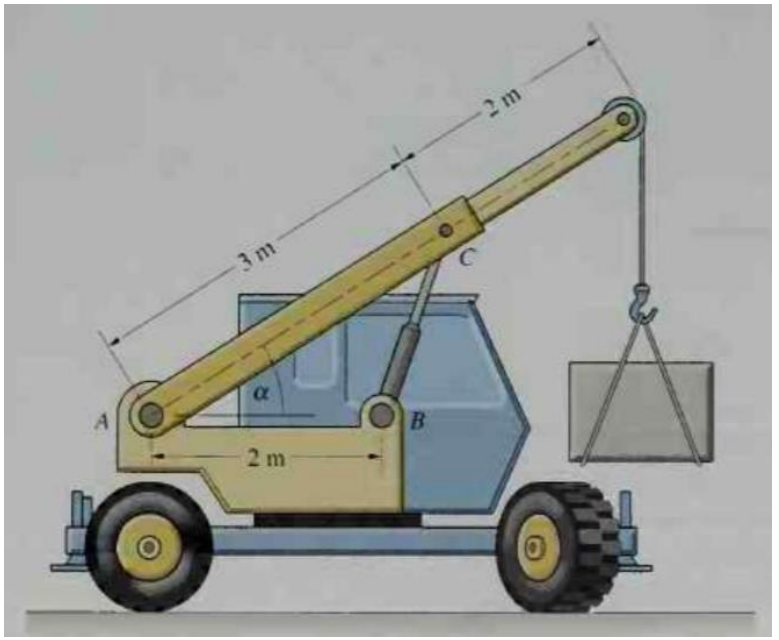
Question:

The hydraulic actuator BC exerts a force at C that points along the line from B to C. Treat A as a pin support. The mass of the suspended load is W. if the actuator BC can exert a maximum force of P, what is the smallest permissible value of α ? W can vary from 2000 kg to 8000 kg and P can vary from 60 kN to 180 kN.



Equilibrium of rigid body in 2D has 3 equations

$$\Sigma Fx = 0$$

$$\Sigma Fy = 0$$

$$\Sigma M_A = 0$$

We will be seeing two cases:

Case 1:

We will give the value for α and weight of the block to find the value of p.

Case 2:

We will give the value for p and weight of the block to find the value of α

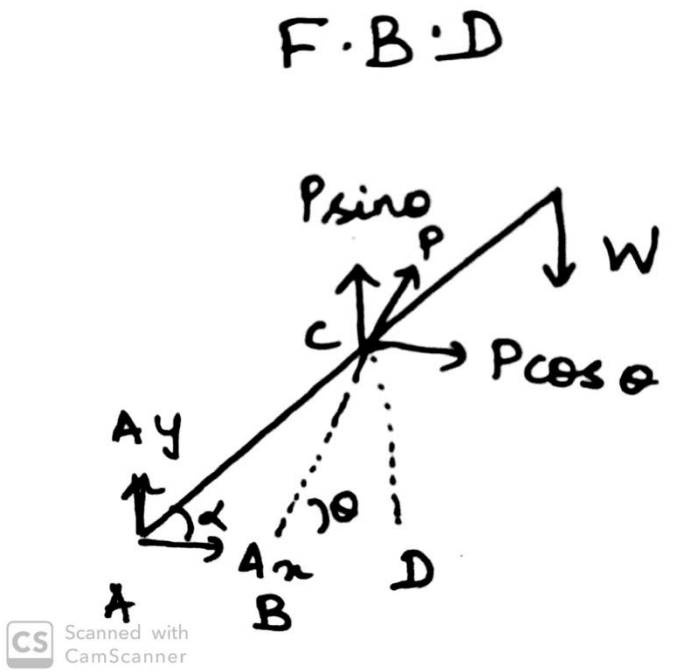
Case 1: P, Ax & Ay are unknowns

α and W are inputs from the user

Consider:

α = 30

W = 6000kg



To find θ:

Consider ΔACD

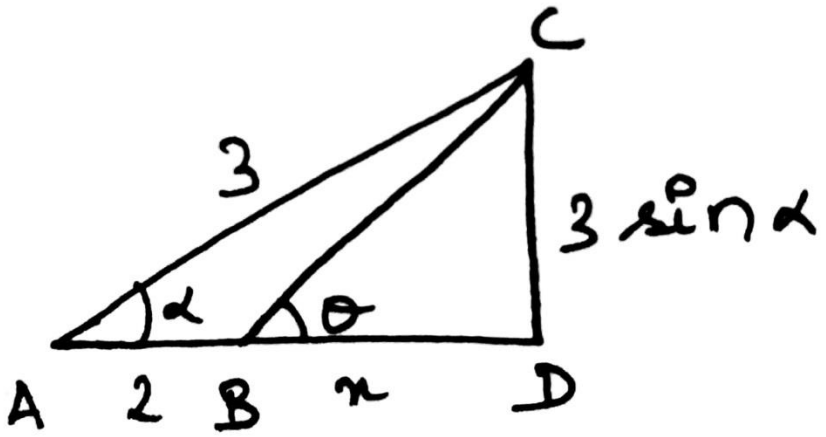
$$2 + x = 3\cos\alpha$$

$$x = 3\cos\alpha - 2$$

$$\tan\theta = \frac{3\sin\alpha}{3\cos\alpha - 2}$$

$$\boxed{\theta = \tan^{-1}\left(\frac{3\sin\alpha}{3\cos\alpha - 2}\right)}$$

$$\theta = 68.26^{o}$$



To find P:

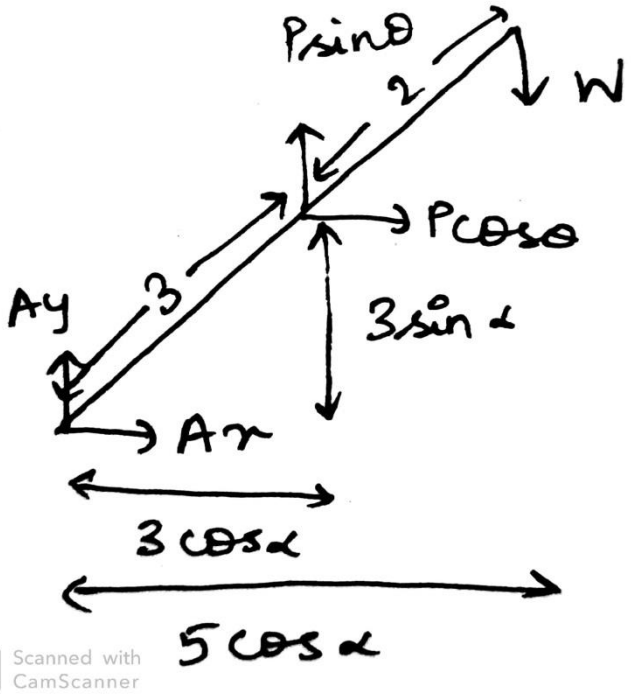
$$\Sigma M_A = 0$$

$$3\cos\alpha * (P\sin\theta) - 3\sin\alpha * (P\cos\theta) - 5\cos\alpha * (W * 9.81) = 0$$

$$3P\sin(\theta - \alpha) = (5\cos\alpha)(W * 9.81)$$

$$\boxed{P = \frac{5\cos\alpha * W * 9.81}{3\sin(\theta - \alpha)}}$$

P = 137191.76N



Case 2:

α, Ax & Ay are unknowns

P and W are inputs from the user

To find $\propto$

We've used a "for" loop in our Java code to find the corresponding $\propto$ that satisfies the following equation:

$$3P\sin(\theta-\alpha)-5\cos\alpha * W * 9.81 = 0$$

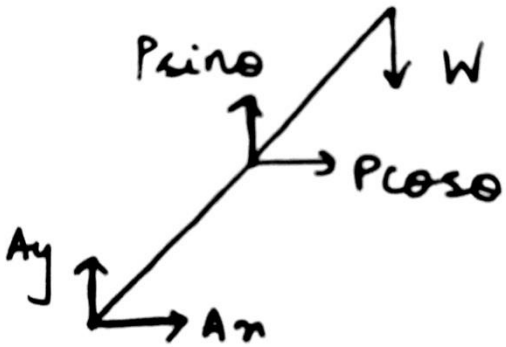
$$where\ \theta = \tan^{-1}\left(\frac{3\sin\alpha}{3\cos\alpha - 2}\right)$$

To find Ax:

$$\Sigma Fx = 0$$

$$Ax + P\cos\theta = 0$$

$$\boxed{Ax = -P\cos\theta}$$



Where P, θ are known from previously solved equations

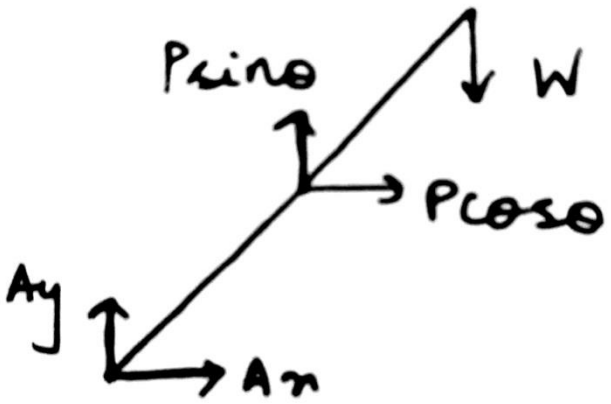
To find Ay:

$$\Sigma Fy = 0$$

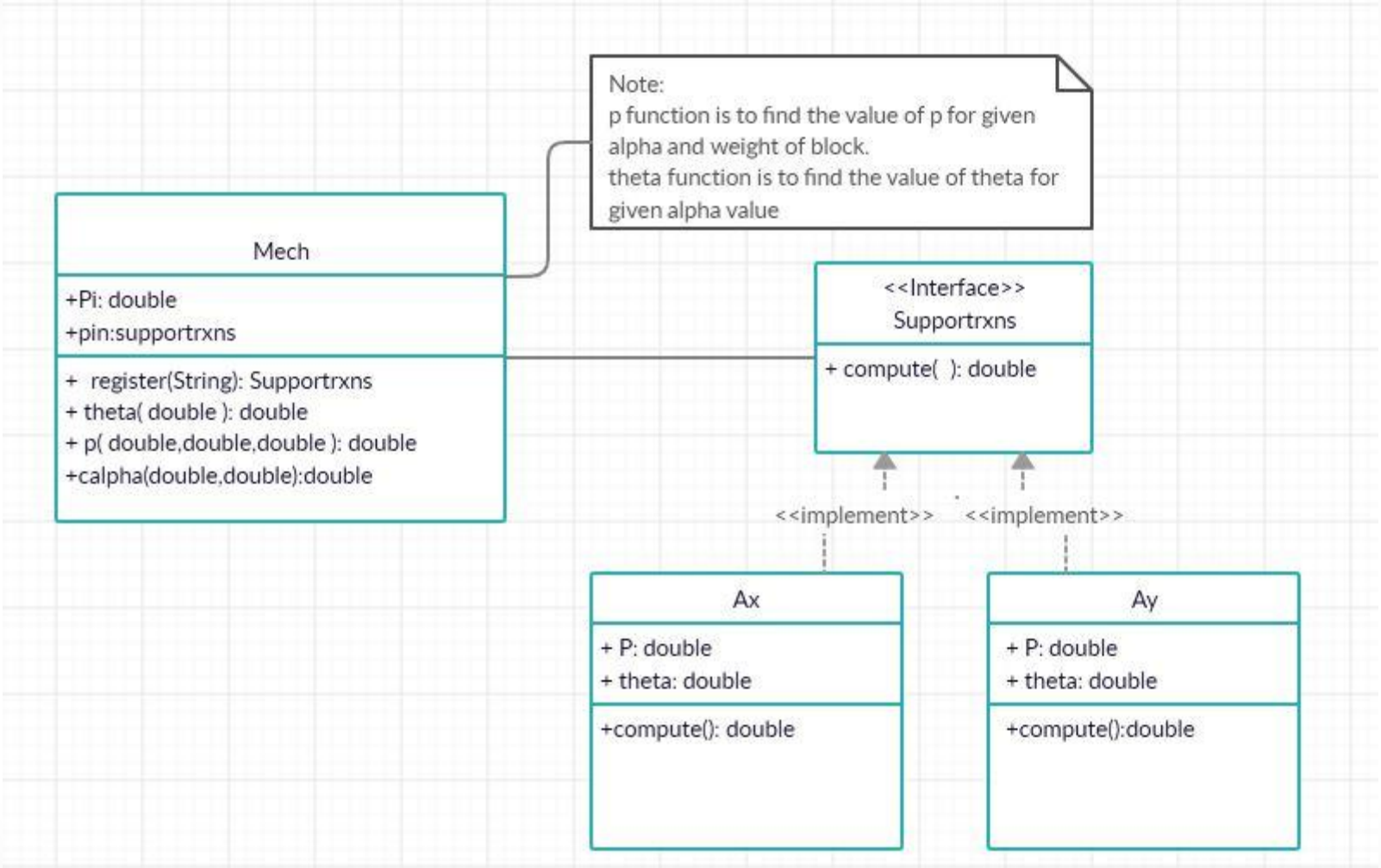
$$Ay + P\sin\theta - W = 0$$

$$\boxed{Ay = W - P\sin\theta}$$

$$\text{Ay} = \text{-}68575.64\text{N}$$



Where W, P, and θ are known from previously solved equations


Note:
p function is to find the value of p for given alpha and weight of block.
theta function is to find the value of theta for given alpha value
Mech
+Pi: double
+pin:supportrxns
+ register(String): Supportrxns
+ theta(double): double
+ p(double,double,double): double
+calpha(double,double):double
<<Interface>>
Supportrxns
+ compute( ): double
<<implement>>
<<implement>>
Ax
+ P: double
+ theta: double
+compute(): double
Ay
+ P: double
+ theta: double
+compute():double

```
public class Mech {
static Supportrxns[] pin = new Supportrxns[5];
static int count = 0;
public static void register(Supportrxns r)
{
pin [count ++] = r;
}
public  Mech() {
for(int i = 0; i < count ; i++)
{ pin[i].compute();
}
}
public double pi=java.lang.Math.PI;
public double theta(double n)
{
double z;
z=180/pi*java.lang.Math.atan(3*java.lang.Math.sin(pi/180*n)/(3*java.lang.Math.co
s(pi/180*n)-2));
return z;
}
```

```
public double P(double w,double a,double th) {
double x;
x=5*java.lang.Math.cos(pi/180*a)*w/(3*java.lang.Math.sin(pi/180*(th-a)));
return x;
}
public double calpha(double w,double P) {
double z,res = 0;
double th;
for( double a=0.0;a<=90;a+=0.1){
th=180/pi*java.lang.Math.atan(3*java.lang.Math.sin(pi/180*a)/(3*java.lang.Math.cos(pi/
180*a)-2));
z=3*java.lang.Math.cos(pi/180*a)*P*java.lang.Math.sin(pi/180*th)-
3*java.lang.Math.sin(pi/180*a)*P*java.lang.Math.cos(pi/180*th)-
5*java.lang.Math.cos(pi/180*a)*w;
 if (z>-1 && z<1)
 {
  res=a;
        System.out.println(a);
        break;}
}
return res;
}
```

```
public static void main(String[] args) {
Mech T1=new Mech();
Mech T2=new Mech();
double theta,P;
//case 1
Scanner sc=new Scanner(System.in);
System.out.print("give value of alpha:");
double alpha=sc.nextDouble();// geting alpha from user
theta=T1.theta(alpha);
System.out.println(theta);//finding theta using alpha given
System.out.print("give value of weight of block:");
double w=sc.nextDouble();//getting weight from user
P=T1.P(w*9.81, alpha, theta);// calculating P
System.out.println(P);
double alpha2=T1.calpha(w*9.81,P);
System.out.println("alpha2="+alpha2);// check if the obtained alpha is eqqual to alpha given
Ax a1 = new Ax(P, theta); //finding Ax
Ay a2 = new Ay(P, w*9.81, theta);// finding Ay
Mech.register (a1);
Mech.register (a2);
Mech T3=new Mech();
```

```
//case 2
System.out.print("give value of P:");
double P1=sc.nextDouble();//getting P from user
System.out.print("give value of weight of block:");
double w1=sc.nextDouble();//getting weight from user
double alpha1=T2.calpha(w1*9.81, P1);
System.out.println("alpha1="+alpha1);
Ax a3 = new Ax(P1, theta); //finding Ax
Ay a4 = new Ay(P, w*9.81, theta);// finding Ay
Mech.register (a3);
Mech.register (a4);
Mech T4=new Mech();}
} interface Supportrxns{
public double compute();
}
class Ax implements Supportrxns{
  double pi=java.lang.Math.PI;
  double p;
  double th;
  double Ax;
public Ax(double n,double t) {
p=n;
th=t;
}
```

```
public double compute() {
Ax=-p*java.lang.Math.cos(pi/180*th);
System.out.println("Ax= "+ Ax);
return Ax;
}
}
class Ay implements Supportrxns{
 double pi=java.lang.Math.PI;
   double p;
   double th;
   double Ay;
   double w;
   public Ay(double n,double m,double t) {
   p=n;
   th=t;
   w=m;
   }
@Override
public double compute() {
Ay=w-p*java.lang.Math.sin(pi/180*th);
System.out.println("Ay= "+Ay);
return Ay;
}
```

As we have two support reactions because of pin support Ax and Ay .we need to inherit Ax and Ay from support reactions ,Hence here we are using the interface concept where the methods in the interface class is completely abstract .

We can’t create object for supportrxns so here we are just creating reference of object

“static Supportrxns[] ***pin = new Supportrxns[5];”***

THANK YOU