

a) Define "Robot" what can a robot do? How can you classify the robot?

Definition of robot:-

A robot is a machine that can do task automatically. It works by following instructions given by humans or a computer program. Some robot look like humans, Some look like machine.

what can a robot do?

- Robots can move things.
- They can build cars in factories
- Some robots can clean house.
- Modern robots can even talk, walk and play.

How to classify (group) robots:-

Robots can be classified into different types:-

- i. Industrial robots - works in factories (cars built robots).
- ii. Service robot - Helps human (hospital, cleaning, works, home).
- iii. Humanoid Robots - looks like to human.
- iv. military Robots - Used in army in defence.

5. Space robot - work in space example
Mars Rover.

6. Agricultural robots - Help in farming (planting,
harvesting crops)

7. Medical robots: used in surgery on patient care

8. Autonomous mobile robots:
move by themselves.

9. Teleoperated robot: controlled from far way.

10. Swarm robot. many small robots work
together ants or bee.

11. Exploration robots: used in dangerous place.

12. Domestic Robots: used in home.

Q. What are the basic components of a robotic system?
State the main function of each of the components.
Components of a robot:-

1. Sensors - collect data from the environment.
(eyes, ears of robot.)

2. Actuators/motors - moves the robotic parts of objects. (legs, arms)

3. Manipulators - The robot's mechanical arms used to pick, hold, move objects.

4. Controller (processor/ECU):-

The brain of the robot. It processes data and makes decisions.

5. Software :-

The set of programs that tell us the robot what to do.

6. power supply:-

provide energy (battery, solar, electric supply)

7. End effect:-

The tool at the manipulators

Example: gripper, - welding torch.

C. write a short notes on:

i) manipulators

ii) End effector

manipulators :-

- manipulators
- A manipulators is a mechanical arms of a robots.
 - It has different joint (like elbow, wrist) which help it move.
 - Main work pick, move, or place objects.
 - without manipulators robot cannot physical works.

End effectors :-

- End Effectors
- End Effectors is the tool attached at the end of manipulators.
 - It helps the robots to specific jobs.
 - Example : Gripper, to hold things.
 - End effector change depending on the robots works.

Q. a) what is sensor? Explain the mechanism of following sensors with their applications?

i) ultrasonic distance sensors

ii) Eddy current proximity sensors

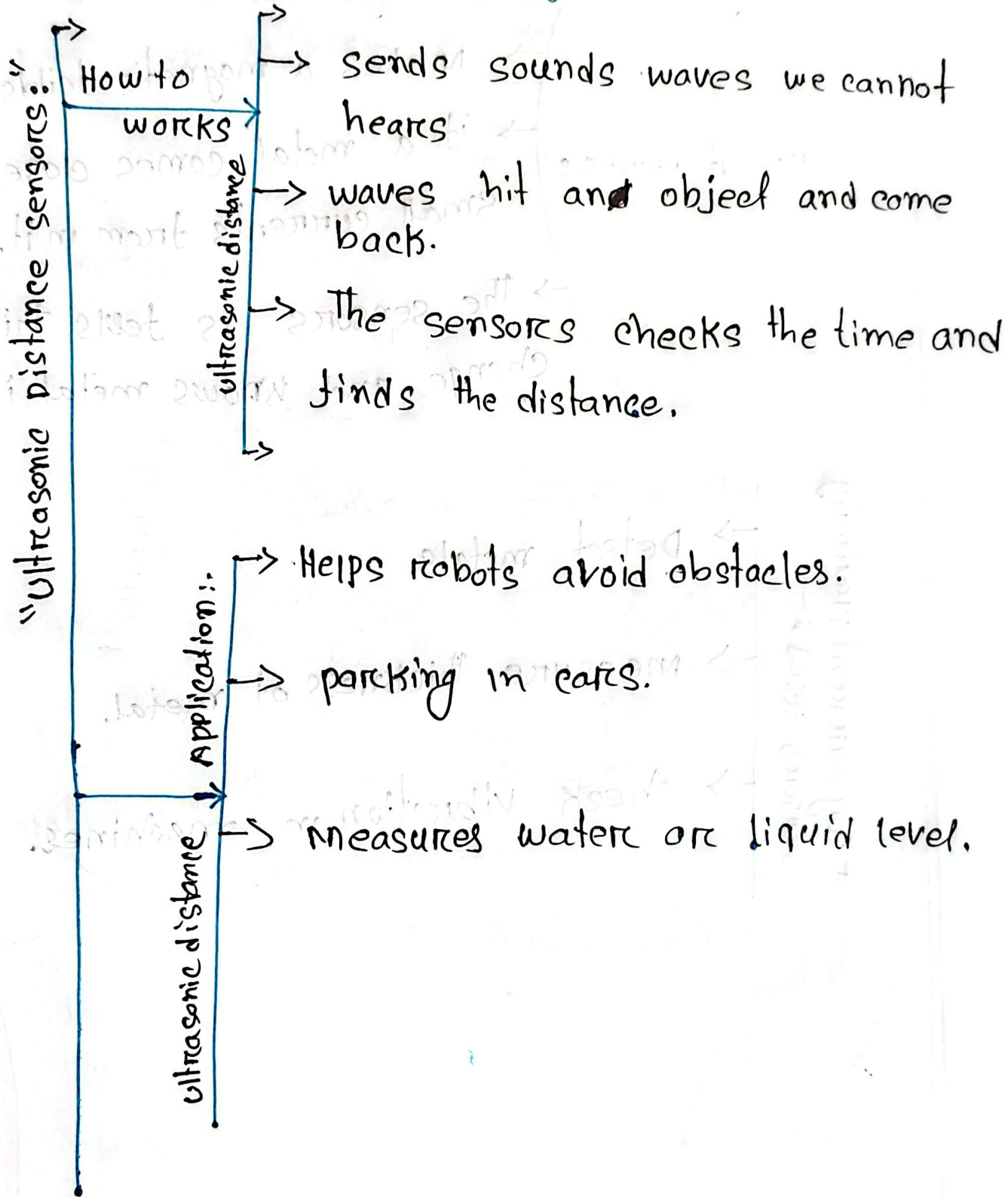
iii) piezoelectric sensors.

what is a sensor?

⇒ A sensor is a device that can feel changes in the environment and send information to the robot or machine.

Types of sensors with mechanism and application:-

i) Ultrasonic distance sensor:



11. Eddy current proximity sensors:-

How it works:

- Makes a magnetic fields.
- if a metal comes close, small currents form in it.
- The sensors is tells this change and knows metal is near.

Eddy current proximity sensors uses:-

- Detect metals
- measure thickness of metal.
- check vibration in machines.

iii) piezoelectric sensors :-

How it works :-

- The sensor measures this electricity.
- Some crystals (like quartz) make electricity.

• Use :-

- microphones
- measures vibration and pressure
- used in ultrasound medical tools.
- detect knocks in machines.

Q.6. what is meant by Robot actuator? what are the different types of actuator used for robot?

Robots Actuators:-

A robot actuator is a part that makes that robot move or do work.

It changes energy into motion.

Types of actuators in Robots:-

1. Electric Actuators:-

- use electric motors
- Example: Dc motor, Stepper motor, Servo motor.
- use: small robots,

~~Hydrex~~ Hydraulic

2. Hydraulic Actuators:-

- use liquid pressure (oil).
- very powerful, can lift heavy loads.
- use: Big robots, construction machines.

3. pneumatic Actuators:-

- use compressed air.
- move fast but not as strong as hydraulic.
- use: pick-and-place robots, factory automation.

4. Thermal or shape memory Actuators:-

- use special materials that changes shape with heat.
- use: small medical robots, micro-robots.

5. Magnetic Actuators:-

- use magnets to create motion.
- use: special precision robots.

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Q. c. Define and describe the forward kinematics and inverse kinematics :-

Forward kinematics :-

Forward kinematics is the process of finding the position and orientation of robot's end effector, when we know the values of the robot's joint angles.

Description :-

Input $\rightarrow$ joint angles (θ_1, θ_2)

output $\rightarrow$ position (x, y, z) and orientation of end effector.

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Input $\rightarrow$ Joint angles (θ_1, θ_2)

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Inverse kinematics:-

Inverse kinematics is the process of finding the joint angles when we know the desired position and orientation of the robots end effector.

Input $\rightarrow x, y, z$

output $\rightarrow \theta_1, \theta_2, \dots$

~~X~~

$F(\text{robot variables}) = \text{world coordinates.}$

$$x = x(\theta_1, \theta_2, \dots)$$

$$y = y(\dots)$$

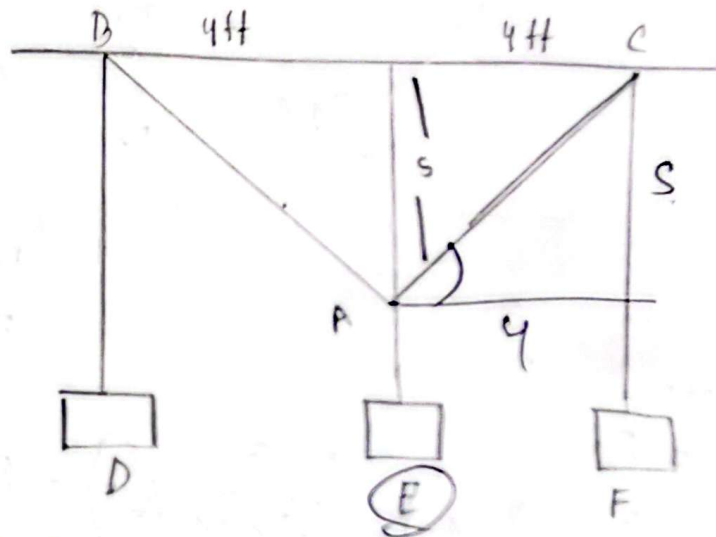
$$x' = l_1 \cos \theta_1 + l_2 \cos(\theta_1 + \theta_2)$$

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

4.e. write down the difference between field and service robots. Also explain robot control methods.

3.13

Given that,
blocks D and F weight 5lb, each and the
weight of block 'E' is 8lb.



We know that,

$$\begin{aligned} \sum F_y &= 0. \\ \Rightarrow F_E \left(\frac{5}{\sqrt{5^2 + 4^2}} \right) + F_F \left(\frac{5}{\sqrt{5^2 + 4^2}} \right) - 8 &= 0. \\ \Rightarrow 5 \times \frac{5}{\sqrt{5^2 + 4^2}} + 5 \times \frac{5}{\sqrt{5^2 + 4^2}} &= 8 \\ \Rightarrow \frac{55 + 55}{\sqrt{5^2 + 16}} &= 8 \end{aligned}$$

$$\Rightarrow 105 = 8\sqrt{5^2 + 16}$$

$$\Rightarrow 1005^2 = 645^2 + 1024$$

$$\Rightarrow 365^2 = 1024$$

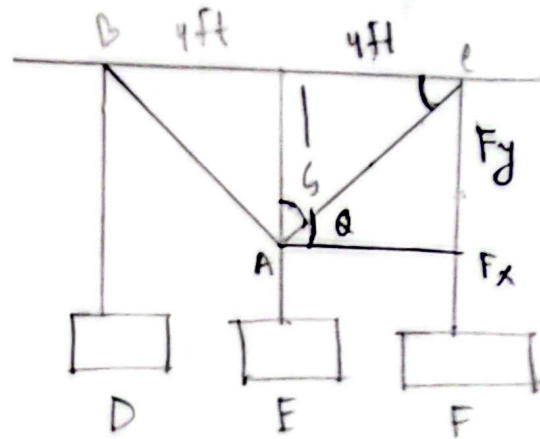
$$\Rightarrow 5^2 = 28.44$$

$$\Rightarrow 5 = 5.33 \text{ ft}$$

(Answer).

(3.14)

Given that,
block D and F weight 5 lb each. The Sag =



$$\sin \theta = \frac{3}{5}$$

We know,

$$\sum F_y = 0$$

$$\Rightarrow F_E \left(\frac{3}{\sqrt{3^2 + 4^2}} \right) + F_F \left(\frac{3}{\sqrt{3^2 + 4^2}} \right) - F_E = 0$$

$$\Rightarrow F_E = 5 \times \frac{3}{5} + 5 \times \frac{3}{5}$$

$$= 3 + 3$$

$$= 6 \text{ lb}$$

$\therefore$ Weight of block E is 6 lb.

(Ans)

Q

(3.25)

Given that,

The springs on the rope assembly are originally stretched 1ft when $\theta = 0^\circ$.

So, $x_0 = 1\text{ft}$

if $\theta = 30^\circ$ then

$$AB = AD = \frac{2}{\cos \theta} = \frac{2}{\cos 30^\circ} = 2.309$$

$$\therefore x = 1 + (2.309 - 2) = 1.309$$

We know that,

$$\begin{aligned} F_s &= kx \\ &= 30 \times 1.309 \\ &= 39.27\text{lb} \end{aligned}$$

$$\begin{aligned} AB &= \frac{2}{\cos \theta} \\ \cos \theta &= \frac{2}{AB} \\ \text{at } 0^\circ \\ AB &= 2 \\ \text{at } 30^\circ \\ AB &= 2.309 \end{aligned}$$

now, $2F_s \sin \theta = F$

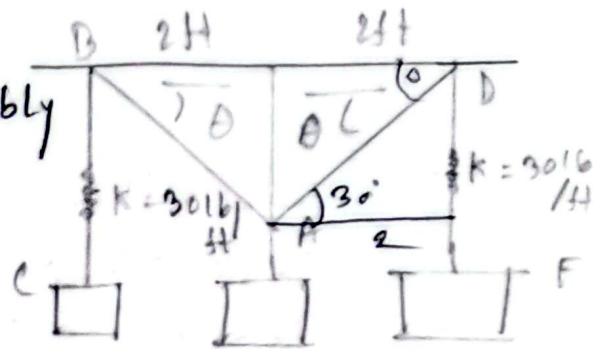
$$\Rightarrow 2F_s \sin 30 = F$$

$$\Rightarrow 2 \times 39.27 \times \frac{1}{2} = F$$

$$\Rightarrow F = 39.27\text{lb}$$

So, the vertical force F is 39.27lb.

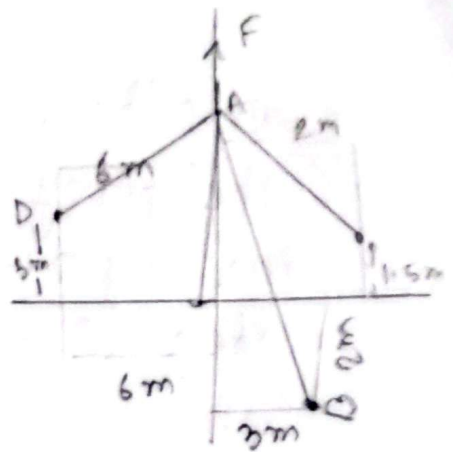
(Answer)



Lecture-3

(3.44)

Given that,
Cable AB is subjected to
tension of 700 N. So, $F_B = 700$



Now,

$$F_c = F_c \left| \frac{-1.5i + 2j - 6k}{\sqrt{(-1.5)^2 + 2^2 + (-6)^2}} \right|$$

$$= -\frac{1.5}{40.25} F_c i + \frac{2}{40.25} F_c j - \frac{6}{40.25} F_c k$$

$$= -0.0373 F_c i + 0.0497 F_c j - 0.149 F_c k \quad \text{--- (i)}$$

$$F_B = F_B \left| \frac{2i + 3j - 6k}{\sqrt{(2)^2 + (3)^2 + (-6)^2}} \right|$$

$$= 700 \times \frac{2i + 3j - 6k}{7}$$

$$= 200i + 300j - 600k \quad \text{--- (ii)}$$

$$F_D = F_D \left| \frac{-3i - 6j - 6k}{\sqrt{(-3)^2 + (-6)^2 + (-6)^2}} \right|$$

$$= -0.333 F_D i - 0.667 F_D j - 0.667 F_D k \quad \text{--- (iii)}$$

and,

$$F = F_k \quad \text{--- (iv)}$$

We know that,
equilibrium requires,
 $\sum F = 0$

$$\therefore F_B + F_C + F_D + F = 0$$

$$\Rightarrow 210i + 300j - 600k - 0.2307 F_C i + 0.307 F_C j - 0.923 F_C k - 0.333 F_D i - 0.667 F_D j - 0.467 F_D k + F_k = 0$$

Equation the respective i, j, k components to zero,

$$\Sigma F_x = 0$$

$$\Rightarrow 200 - 0.333 F_D - 0.2307 F_C = 0 \quad \text{--- (v)}$$

$$\Sigma F_y = 0$$

$$300 - 0.667 F_D + 0.307 F_C = 0 \quad \text{--- (vi)}$$

$$\Sigma F_z = 0$$

$$-600 - 0.667 F_D - 0.923 F_C + F = 0 \quad \text{--- (vii)}$$

From equation (v) we see that,

$$0.2307 F_C + 0.333 F_D = 200$$

$$\Rightarrow 0.333 F_D = 200 - 0.2307 F_C$$

$$\Rightarrow F_D = 600.6 - 0.6927 F_C \quad \text{--- (viii)}$$

Now From eqn (vi)

$$0.307 F_C - 0.667 F_D = -300$$

$$\Rightarrow 0.307 F_C - 0.667 (600.6 - 0.6927 F_C) = -300$$

$$\Rightarrow 0.307 F_C - 400.2 + 0.46203 F_C = -300$$

$$\therefore F_C = 130 \text{ N}$$

$$\therefore F_D = \{ 600.6 - 0.6927 (130) \} \text{ N}$$

$$= 510 \text{ N}$$

Now from eq (vii)

$$-0.667 F_D - 0.023 F_c + F = 600$$

$$\Rightarrow -0.667(510) - 0.023(130) + F = 600$$

$$\therefore F = 1060 \text{ N}$$

So, $F = 1060 \text{ N}$

$$F_D = 510 \text{ N and } F_c = 130 \text{ N}$$

(3.47)

Given that the two springs required to hold the 20 kg crate in the equilibrium position.

$$\therefore W = -(20 \times 9.8) \text{ kN}$$

$$= -196 \text{ kN}$$

Now, $F_A = -F_A j$ and $F_B = -F_B i$

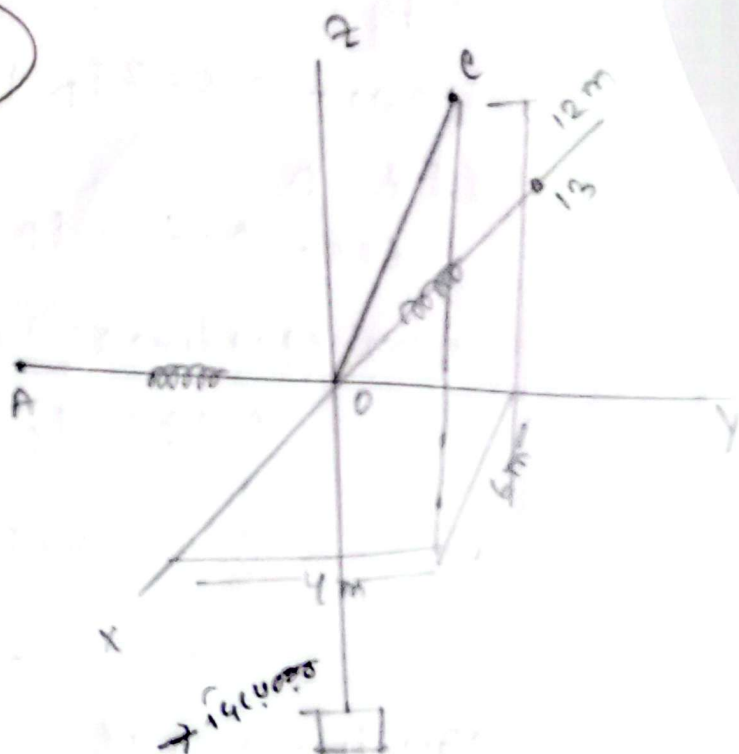
$$\text{and, } F_c = F_c \left| \frac{6i + 4j + 12k}{\sqrt{6^2 + 4^2 + 12^2}} \right|$$

$$= (0.428i + 0.286j + 0.857k) F_c$$

We know that,

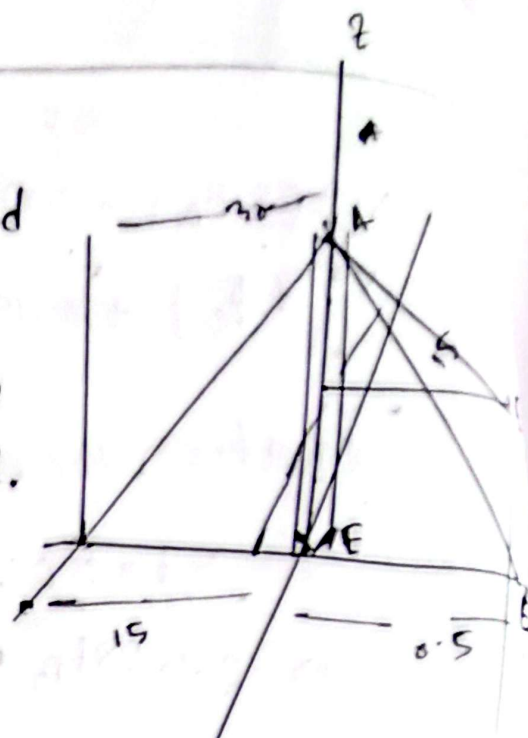
equilibrium requires,

$$\sum F = 0$$



(3.62)

Given that, AD is tightened by the turnbuckle and develop a tension of 1000 lb in either cable AB and AC.



$$F_B = F_B \left| \frac{10i - 15j - 30k}{\sqrt{(10)^2 + (15)^2 + (30)^2}} \right|$$

$$= \frac{2}{7} F_B i - \frac{3}{7} F_B j - \frac{6}{7} F_B k$$

$$F_C = F_C \left| \frac{-15i - 10j - 30k}{\sqrt{(-15)^2 + (-10)^2 + (-30)^2}} \right|$$

$$= -\frac{3}{7} F_C i - \frac{2}{7} F_C j - \frac{6}{7} F_C k$$

$$F_D = F_D \left| \frac{12.5j - 30k}{\sqrt{(12.5)^2 + (-30)^2}} \right|$$

$$= \frac{5}{13} F_D j - \frac{12}{13} F_D k$$

$$F_E = F_E k$$

Equilibrium requires,

$$\Sigma F = 0$$

$$F_B + F_C + F_D + F_E = 0$$

$$\left(\frac{2}{7} F_B - \frac{3}{7} F_C \right) i + \left(-\frac{3}{7} F_B - \frac{2}{7} F_C + \frac{5}{13} F_D \right) j + \left(-\frac{6}{7} F_B - \frac{6}{7} F_C - \frac{12}{13} F_D + F_E \right) k = 0$$

Equation the i, j, k components yields,

$$\frac{2}{7} F_B - \frac{3}{7} F_C = 0 \text{ --- (i)}$$

$$-\frac{3}{7} F_B - \frac{2}{7} F_C + \frac{5}{13} F_D = 0 \text{ --- (ii)}$$

$$-\frac{6}{7} F_B - \frac{6}{7} F_C - \frac{12}{13} F_D + F_E = 0 \text{ --- (iii)}$$

Let us assume that cable AB achieves maximum tension first. Substituting $F_B = 1000 \text{ lb}$ into (i) through (iii) and solving yields,

$$F_C = 666.67 \text{ lb.}$$

$$F_E = 2914 \text{ lb.}$$

$$\text{and, } F_D = 1610 \text{ lb.}$$

Since, $F_C = 666.67 \text{ lb} < 1000 \text{ lb}$, our assumption is correct.