RAMAIAH UNIVERSITY OF APPLIED SCIENCES

ASSIGNMENT

Course Code	ESC106A
Course Name	Construction Materials & Engineering Mechanics
Programme	Bachelor of Technology
Department	Civil Engineering
Faculty	FET

Name of the Student	ALOK KUMAR SINGH
Reg. No	17ETCS002020
Semester/Year	FIRST
Course Leader/s	Ms. Deepthi M. V

Declaration Sheet			
Student Name	ALOK KUMAR SINGH		
Reg. No	17ETCS002020		
Programme	Bachelor of Technology	Semester/Year	FIRST
Course Code	ESC106A		
Course Title	Construction Materials & Engineering Mechanics		
Course Date		to	
Course Leader			

Declaration

The assignment submitted herewith is a result of my own investigations and that I have conformed to the guidelines against plagiarism as laid out in the Student Handbook. All sections of the text and results, which have been obtained from other sources, are fully referenced. I understand that cheating and plagiarism constitute a breach of University regulations and will be dealt with accordingly.

Signature of the Student		Date	
Submission date stamp (by Examination & Assessment Section)			

Signature of the Course Leader and date	Signature of the Reviewer and date

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<u>Question No. A</u>

<u>Solution to Question No. A:</u>

Center of gravity is a point of a body or a system at which the whole mass may be considered as concentrated. The center of gravity lies at the geometrical center of a body whose weight is uniformly distributed. In other word we can say that the center of gravity on each little bit of an object is "gm" where 'g' is local gravitational constant and 'm' is the center of mass.

A1.1 Reasons for the stability of balancing bird and the leaning tower of Pisa

Firstly, lest talk about the balancing bird, we all know what is unique in this balancing bird. But the main concept behind it, is the center of gravity. The bird is balanced due to the uniform center of gravity. This is because of the structure of it. Center of gravity depends on the uniform distribution of mass in a body. And the uniform distribution of mass depends on the design of the body. So, in the balancing bird, the center of mass comes right on the balancing point, right on the tip. Which means the bird is at equilibrium i.e. no force or rotation. Now there are two kinds of equilibrium one is stable and another is unstable. If the center of gravity or center of mass is above the pivot, then a body act like unstable. But if somehow, we managed to get the center of gravity below the pivot point, then the body will be in the stable equilibrium i.e. it always maintains a particular position. Our bird do the same thing. The outstretched wings have weights located at the tips. The wings of the bird are just ahead of the beak and that is where the extra weight is located. this location allows the weight to exert a good bit of torque to the entire bird. So the bird has two things needed to be balanced:

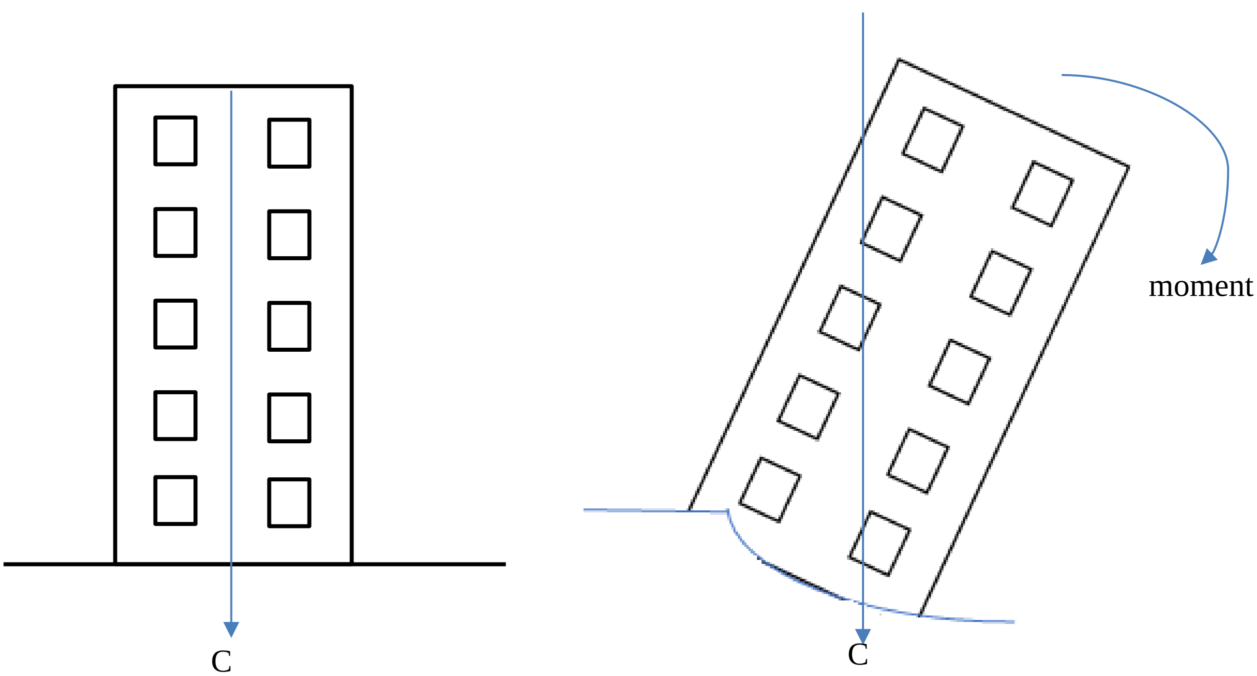
a) The center of gravity should be at the pivot point. Which make the bird in equilibrium i.e. no forces, accelerations and no torque.
b) The center of gravity may be in the right below the pivot point to make the position stable.

Now, talking about the stability of leaning tower of Pisa.it is also based on the center of gravity. According to science, anything will remain stable as long as the vertical line drawn from the center of gravity passes through it base. Till today the vertical line from the center of gravity has been falling within the base of this tower. Ans still the center gravity is not get much affected by the leaning of the tower. One of another reason behind this, is that, the center of gravity of anybody get affected by its base and height i.e. if the base area of an object is less than the height of that object should be less and vice versa. Thus, in the leaning tower of Pisa the base area and height is in the stable ratio. That is why the stability of the center of gravity of the tower is still maintained.

A1.2 Importance of center of gravity with the help of other examples from civil engineering

Center of gravity is very important in every field, whether it in sports, structure of a building or any moving object. The stability of anything in earth or in another planet is depend on the center of gravity. If the center of gravity of any object get disturbed or not stable, then it will fall. Like in news, we use to listen that a building fallen down due to any phenomenon. That phenomenon is the first cause, but the main cause of that incident is due to the shifting of center of gravity. Like a building fallen down due to soil erosion under the ground of that building. Due to this the building lean with some angle and the center of gravity get disturbed or and get shifted. Which results the destruction of that building. Taking an example to understand the importance of center of gravity:

on 11t December 1993 in Taman Hillview, Ulu Klang, Selangor, Malaysia. The highland tower collapse, due to the water content in the soil had turned viscous, by which the soil of the ground of the building became muddy. One side of the building lean down due the breakage of foundation of that side. The upper part of the building was much Havier than the lower part which exerts large amount of force on leaned side. the equilibrium of the building gets disturbed due to which the center of gravity get shifted towards another side or we can say that the vertical line drawn from the center of gravity passes through it base is no longer stable (as shown in the figure A1.2). And due to the height of the building, the moment of inertia effects the center of gravity heavily. As the result the building collapse completely.



The center of gravity of building was in equilibrium before fallen down

The center of gravity of building get disturbed due to which moment of inertia produce

Fig A.1.1 rough diagram to demonstrate how the disturbed center of gravity affect the stability of building (collapse the building).

A1.3 Stance taken with justification and conclusion

According to me Location of center of gravity is the only factor that governs the stability of any structure. Without taking measurement of center of gravity none of the structure can be made. If one makes a structure without keeping in his mind about center of gravity, he/she can never build any structure. Center of gravity is the basic stability of any structure. Keeping in the mind about this a best structure has been made. For example, burg Khalifa, the tallest building till now. It is very stable because the engineers took all the center of gravity or center of mass on its middle base. And the according to the height, the base of the building is very large, which promotes a stable equilibrium and maintain a stable structure with stable center of gravity.

Question No. B

Solution to Question No. B1:

B1.1 free body diagram

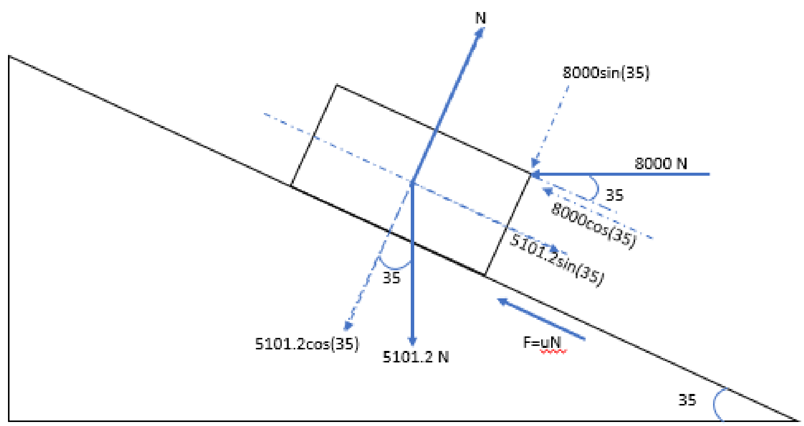


Fig 1.1 free body diagram with the 8000 N force applied on the baggage

B1.2 Determination of frictional force on the baggage for given horizontal load

given,
weight of baggage (500+20) × 9.81 = 5101.2 N
let F and N be the friction and normal force respectively, where F = uN

Applying the condition of equilibrium:

$$\sum F_x = 0$$

-8000cos(35)-F+5101.2sin(35) = 0

F = 5101.2sin(35) - 8000cos(35)

F = -3627.288 N

$$\sum F_y = 0$$

- ⇨ N -5101.2cos(35) – 8000sin(35) = 0
- ⇨ N = 8767.269 N

So, friction in the surface of the inclined body by the baggage will be:

F=uN

$$or, u = \frac{F}{N}$$

u= 3627.288/8767.269

u= 0.4137

hence the coefficient of friction is 0.4137

B1.3 Calculation of minimum load to be applied on the baggage to prevent it from sliding down

Considering the minimum load to be applied o
Now, applying condition of equilibrium:

$$\sum F_y = 0$$

- ⇨ N – Psin(35) – 5101.2cos(35) =0
- ⇨ N – Psin(35) = 4178.658 ----------(1)

$$\sum F_x = 0$$

- ⇨ -F + 5101.2sin(35) – Pcos(35) = 0
- ⇨ 0.4137N + Pcos(35)= 2925.928 ---------

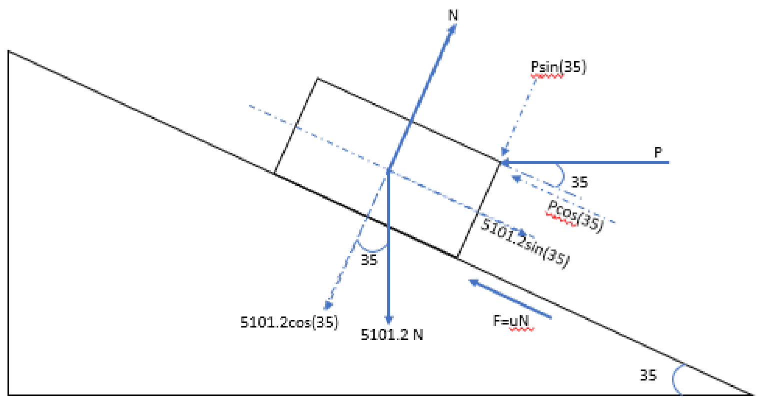


Fig 1.2 free body diagram with the P force to prevent for sliding

From equation (1) and (2)

N = 4828.667 N and P = 1133.255 N

Hence, 133.255 N minimum load should be applied on the baggage to prevent it from sliding down

B1.4 Calculation of the force required to cause the baggage move up the ramp

$$\sum F_y = 0$$

- ⇨ N – 5101.2cos(35) – Psin(35) =0
- ⇨ N –Psin(35) = 4178.658 ---------(3)

$$\sum F_x = 0$$

- ⇨ F – pcos(35) + 5101.2sin(35) = 0
- ⇨ 0.4137N – pcos(35) = -2925.928 -----(4)

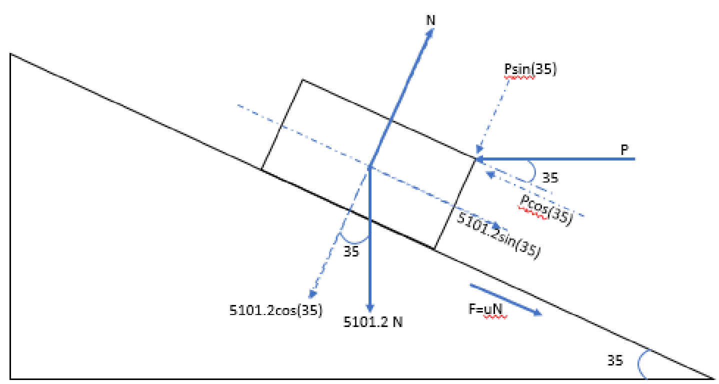


Fig 1.3 free body diagram with the P force to move the baggage up

Form (3) and (4) we get

N = 8767.004 N and P = 7999.5377 N

the force required to cause the baggage move up the ramp is 7999.5377 N

Question No. B2

Solution to Question No. B2:

B2.1 Free body diagram

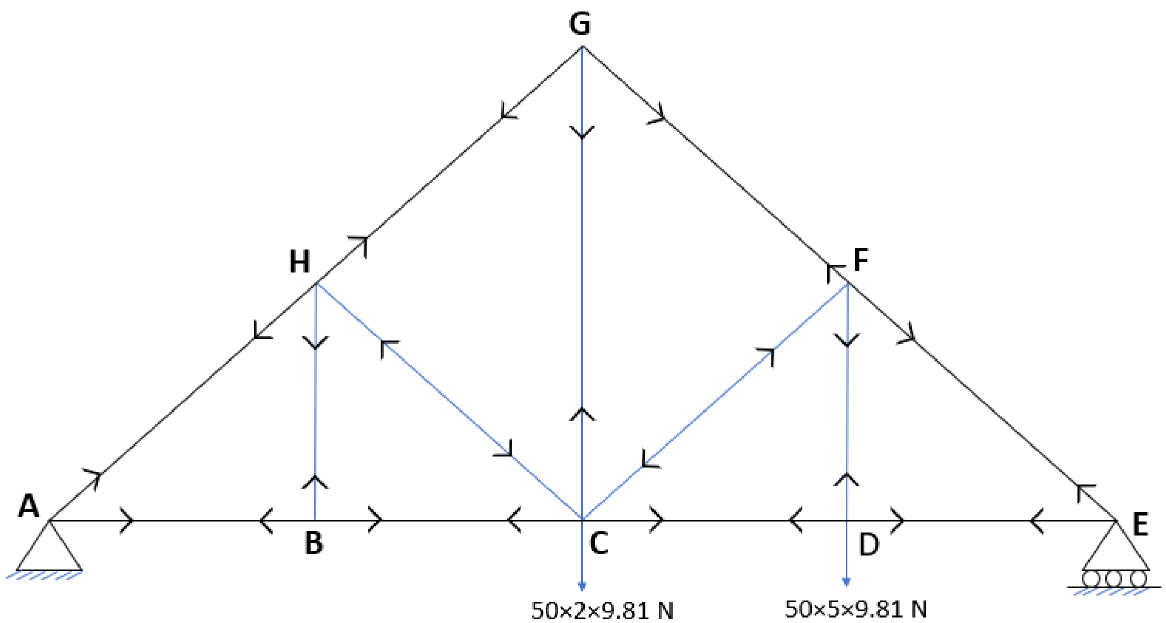


Fig 2.1 free body diagram of B1

B2.2 Calculation of support reactions

free body diagram for the base supports along with the weight

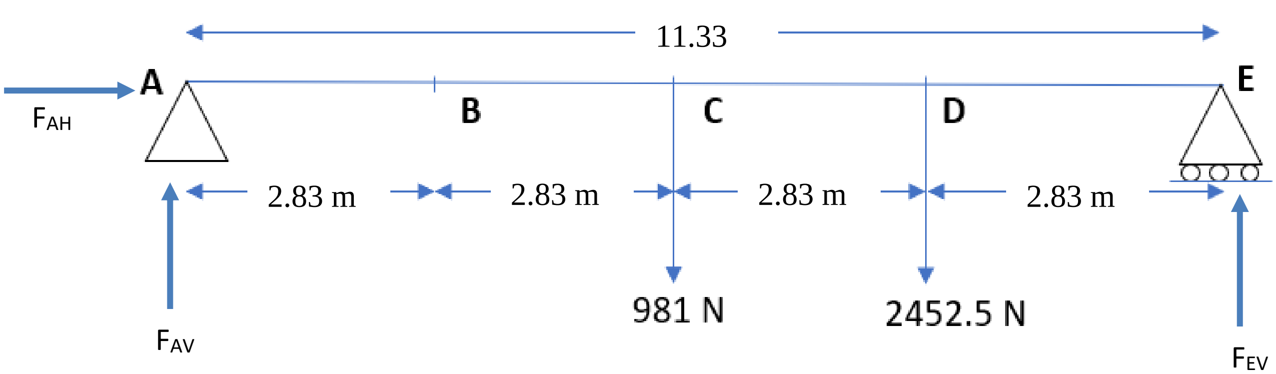


Fig 2.2 free body diagram for supports

The span of the bride is 10 + $x/15$ m where x = 20 so, length of the span will be 10+20/15 = 11.33 m

Since weight of two people is acting at point c therefore force at point C will be 9.81 × 50 × 2 = 981 N And the weight of 5 people is acting on point D so the force will be 9.81 × 50 × 5 = 2452.5 N

Now, applying the condition of equilibrium we get:

$$\sum F_x = 0$$

- ⇨ $F_{AH} = 0$

$$\sum F_y = 0$$

- ⇨ $F_{AV} + F_{EV} - 981 - 2452.5$ N = 0
- ⇨ $F_{AV} + F_{EV} = 3433.5$ ---------------------- 1

Moment along point A

$$\sum M_A = 0$$

- ⇨ $M_A = 981 \times 5.0665 + 2452.5 \times 8.498 - F_{EV} \times 11.33 = 0$
- ⇨ $F_{EV} = 2329.98$ N

From 1

$F_{AV} = 3433.5 - 1103.567$

$F_{AV} = 1103.67$ N

Hence the reactions at point A is $F_{AH} = 0$, $F_{AV} = 1103.67$ N and the reactions at point E is $F_{EV} = 2329.98$ N

B2.3 Calculation of member forces

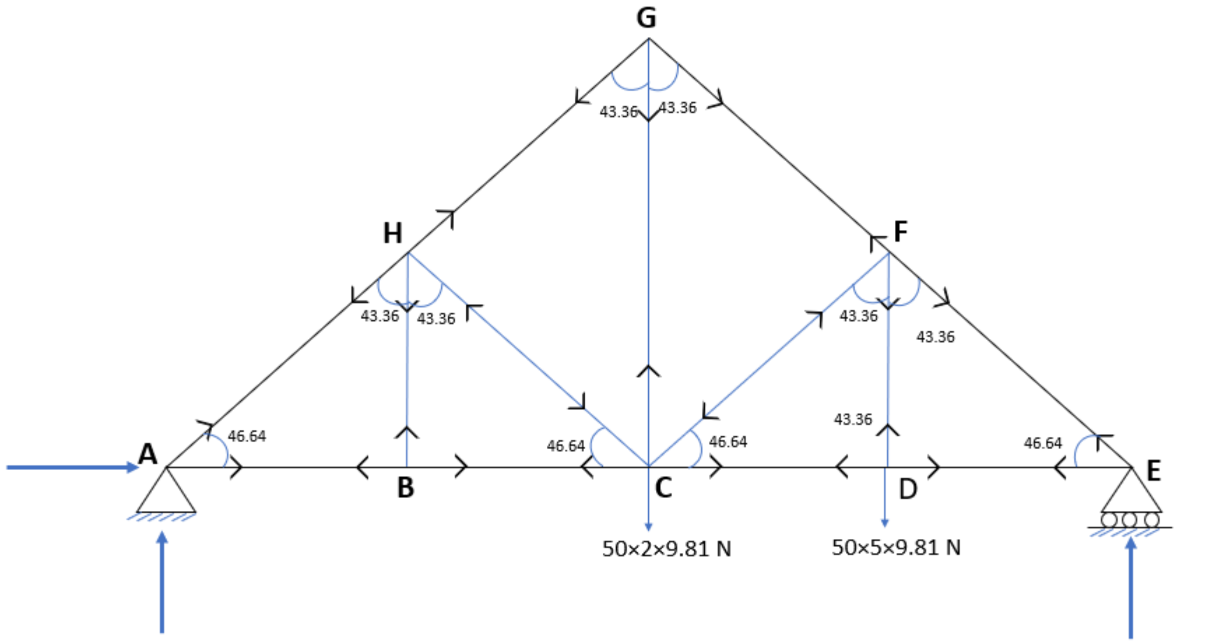


Fig 2.3 FBD with angle and force acting on each supports

Angle BAH = BEF = $\tan^{-1}\frac{6}{5.665}$ = 46.645°

At point E

Appling condition of equilibrium

$$\sum F_Y = 0$$

⇨ 2329.98 + F_{FE}sin(46.64) = 0

⇨ $F_{FE} = \frac{-2329.98}{\sin 46.64}$

⇨ $F_{FE} = -3204.68\ N$

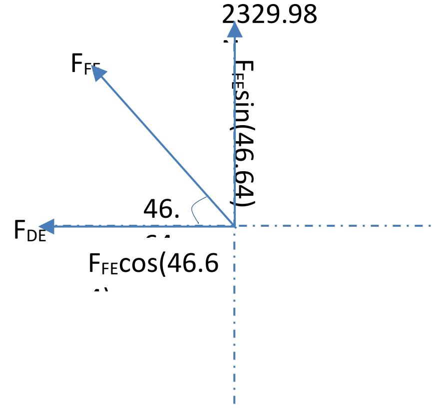


Fig 2.4 forces at point E

$$\sum F_X = 0$$

⇨ $-F_{DE} - F_{FE}\ \text{COS}\ 46.64 = 0$

⇨ $F_{DE} = -(-3204.68)COS46.64$

⇨ $F_{DE} = 2200.27\ N$

At point D

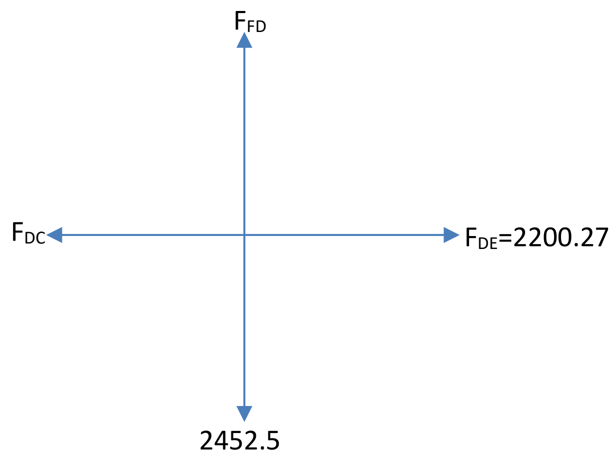


Fig 2.5 forces at point D

Applying condition of equilibrium, we get

$F_{DC} = 2200.27\ N$ and $F_{FD} = 2452.5\ N$

At point F

Applying conditions for equilibrium:

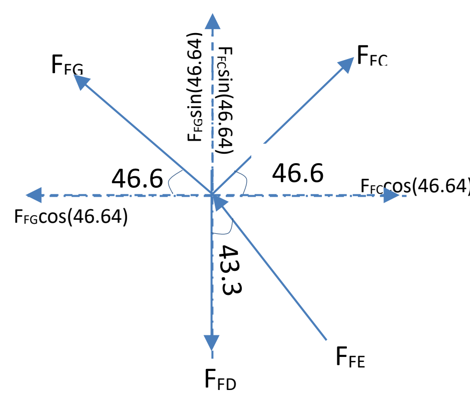


Fig 2.6 forces at point F

$$\sum F_X = 0$$

⇨ $-F_{FG}\cos 46.64 + F_{FC}\cos 46.64 - F_{FE}\cos 46.64 = 0$

⇨ $-F_{FG}\cos 46.64 + F_{FC}\cos 46.64 = 3204.68\cos 46.64$

⇨ $-F_{FG}\cos 46.64 + F_{FC}\cos 46.64 = 2200.27$ --- (1)

$$\sum F_y = 0$$

⇨ $-F_{FD} + F_{FC}\sin 46.64 + F_{FG}\sin 46.64 + F_{FE}\sin 46.64 = 0$

⇨ $F_{FC}\sin 46.64 + F_{FG}\sin 46.64 = 2452.5 - 3204.68\sin 46.64$

⇨ $F_{FC}\sin 46.64 + F_{FG}\sin 46.64 = 122.52$ ----------------------(2)

From (1) and (2)

$F_{FC} = 1686.598\ N \quad and \quad F_{FG} = -1518.08\ N$

From point G

Applying conditions of equilibrium:

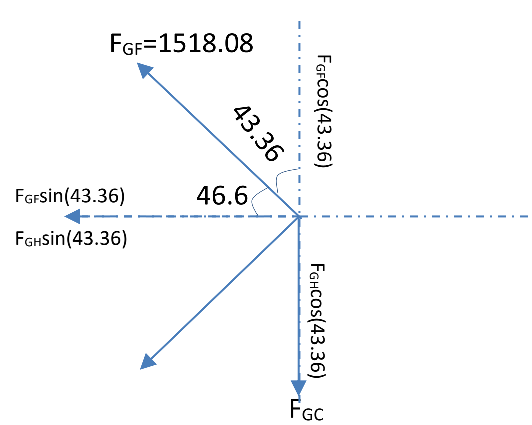


Fig 2.7 forces at point G

$$\sum F_X = 0$$

⇨ $-F_{GF}\sin 43.36 - F_{GH}\sin 43.36 = 0$

$\Rightarrow$ $F_{GH} = \frac{-1518.08 \sin 43.36}{\sin 43.36}$

$\Rightarrow$ $F_{GH} = -1518.08\ N$

$$\sum F_y = 0$$

$\Rightarrow$ $F_{GF} \cos 43.36 - F_{GH} \cos 43.36 - F_{GC} = 0$

$\Rightarrow$ $F_{GC} = F_{GF} \cos 43.36 - F_{GH} \cos 43.36$

$\Rightarrow$ $F_{GC} = 1518.08 \cos 43.36 + 1518.08 \cos 43.36$

$\Rightarrow$ $F_{GC} = 2207.45\ N$

At point C

Applying conditions of equilibrium:

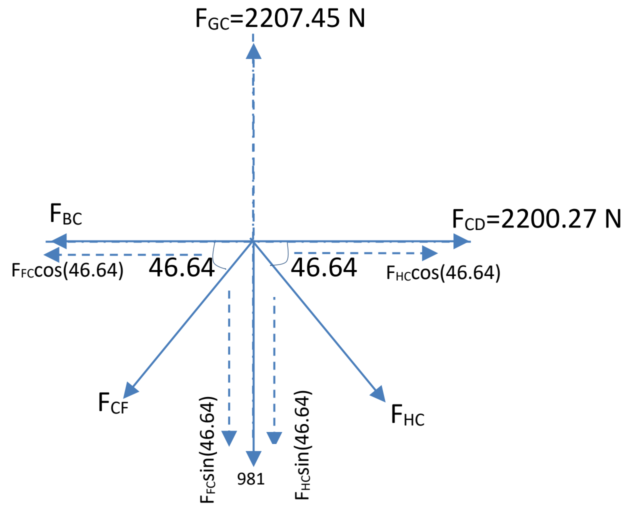


Fig 2.8 forces at point C

$$\sum F_y = 0$$

$\Rightarrow$ $-981 - F_{CF} sin 46.64 - F_{HC} \sin 46.64 + F_{GC} = 0$

$\Rightarrow$ $F_{HC} = \frac{-981+2207.45-1686.598 \sin 46.64}{\sin 46.64}$

$\Rightarrow$ $F_{HC} = 0.201\ N$

$$\sum F_X = 0$$

$\Rightarrow$ $-F_{CF} \cos 43.36 + F_{HC} \cos 43.36 - F_{BC} + F_{CD} = 0$

$\Rightarrow$ $F_{BC} = -F_{CF} \cos 43.36 + F_{HC} \cos 43.36 + F_{CD}$

$\Rightarrow$ $F_{BC} = -1686.598 \cos 43.36 + 2200.27 - 0.201 \cos 43.36$

$\Rightarrow$ $F_{BC} = 1042.13\ \mathrm{N}$

At point

Applying, condition of equilibrium

$$\sum F_y = 0$$

$\Rightarrow$ $1103.567 + F_{AH} sin 46.64 = 0$

$\Rightarrow$ $F_{AH} = -1103.567/sin 46.64$

$\Rightarrow$ $F_{AH} = -1517.86$

$$\sum F_X = 0$$

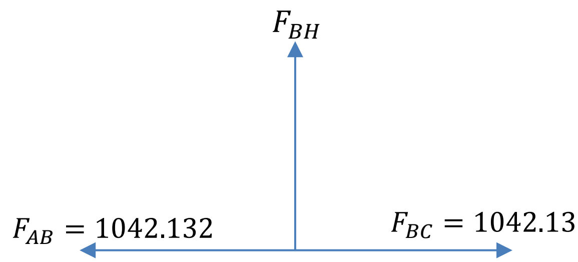
$\Rightarrow$ $F_{AH} \cos 46.64 + F_{AB} = 0$

⇨ $F_{AB} = 1517\cos 46.64 = 10$

⇨

Fig 2.9 forces at point A

<u>at point B</u>



$$\sum F_y = 0$$

⇨ $F_{BH} = 0$

Fig 2.10 forces at point B

Final diagram: -

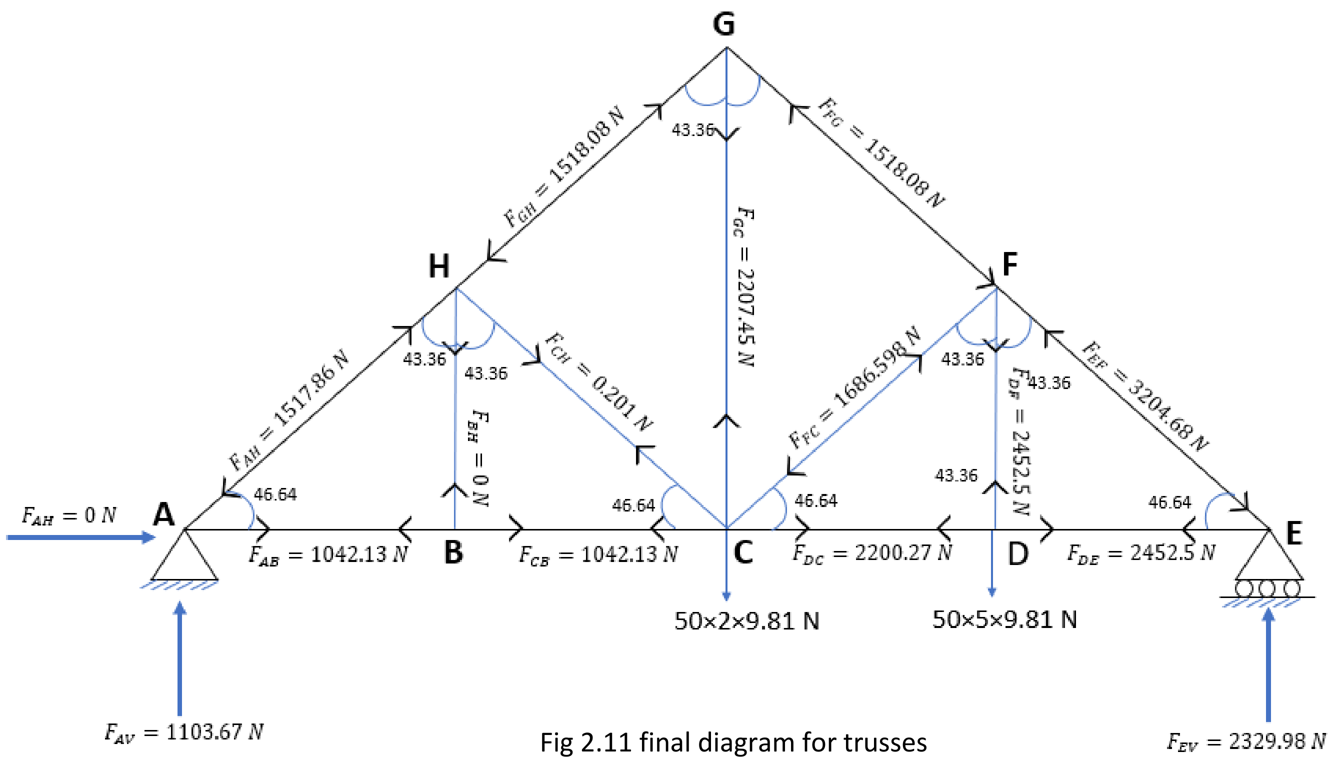


Fig 2.11 final diagram for trusses

<u>s.no.</u>	**<u>Forces</u>**	**<u>Magnitude of forces</u>**	**<u>tension/compression</u>**
1	F_{FE}	3240.68 N	COMPRESSION
2	F_{DE}	2200.27 N	TENSION
3	F_{DC}	2200.27 N	TENSION
4	F_{FD}	2452.5 N	TENSION
5	F_{FC}	1686.598 N	COMPRESSION
6	F_{FG}	1518.08 N	COMPRESSION
7	F_{GH}	1518.08 N	COMPRESSION

8	F_{GC}	2207.45 N	TENSION
9	F_{HC}	0.201 N	TENSION
10	F_{AH}	1517.86 N	COMPRESSION
11	F_{AB}	1042.13 N	TENSION
12	F_{HB}	0 N	TENSION
13	F_{BC}	1042.13 N	TENSION

Table 2.1 final tension and compression on each trusses

Question No. B

Solution to Question No. B3:

B.3.1 Assumption of suitable dimensions

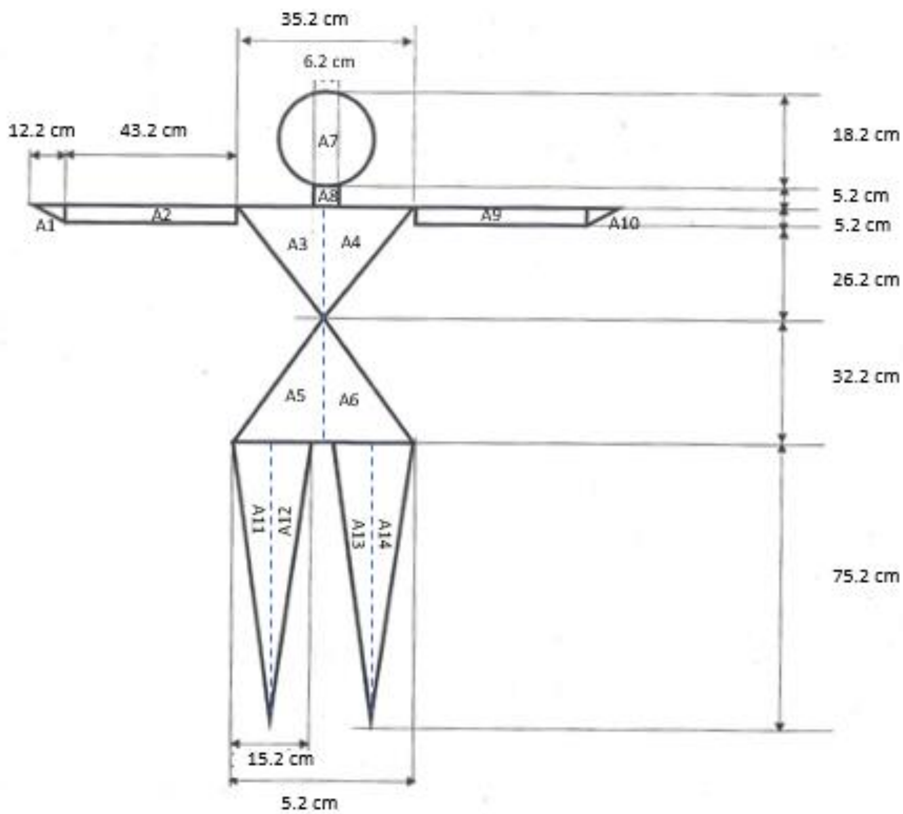
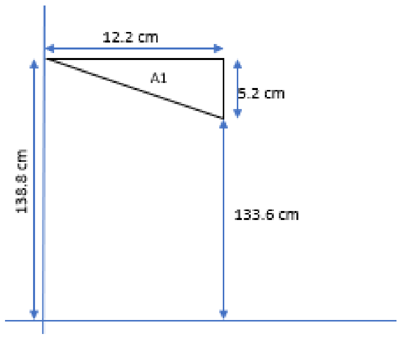
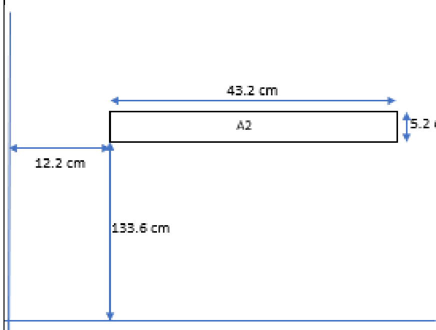
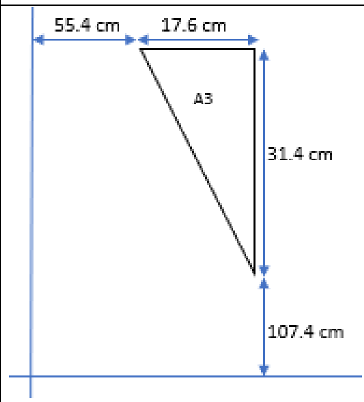
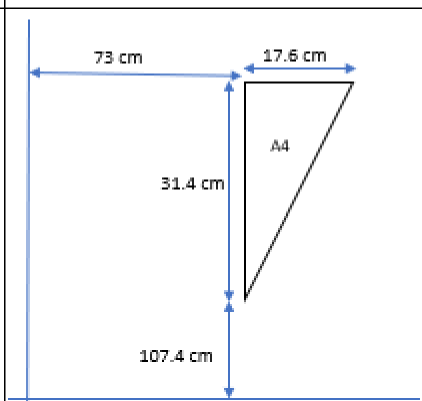
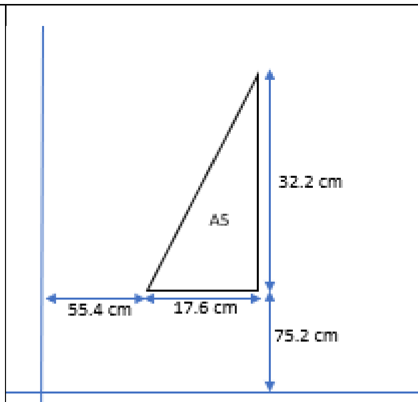
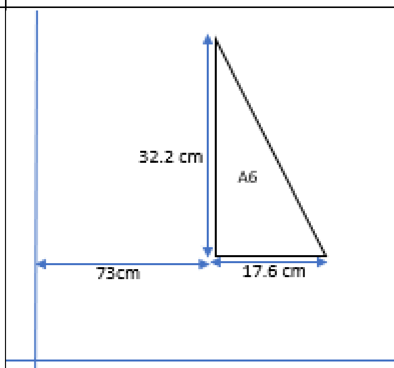
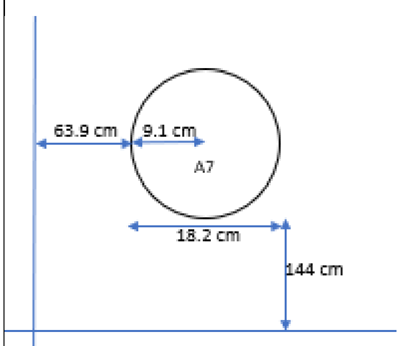
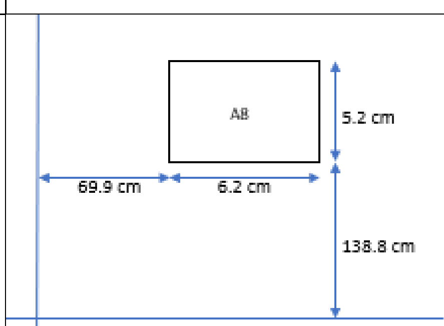


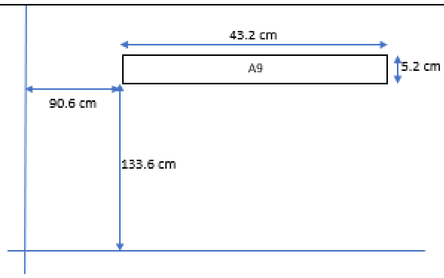
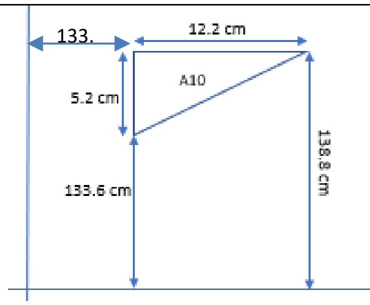
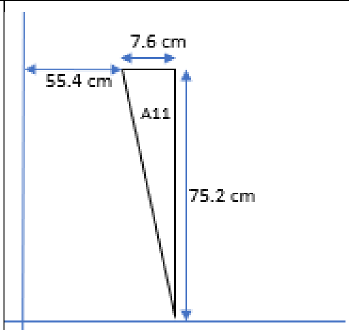
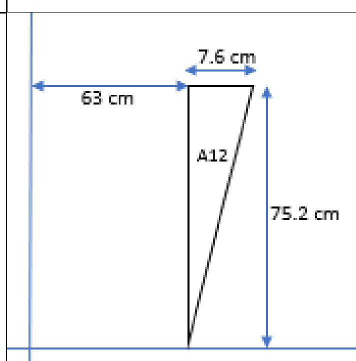
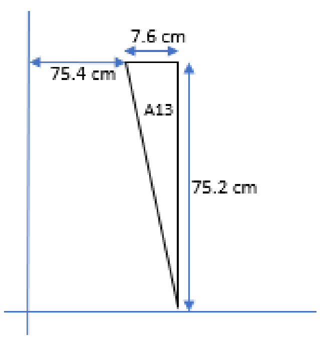
Fig 3.1 FBD by showing suitable dimensions for the question B3

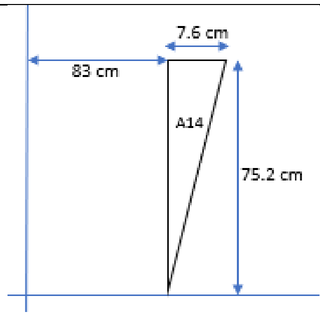
B.3.2 Calculation of center of gravity

Table 3.1 showing area, Xi, yi, AiXi, AiYi for all individual part of body

Fig. no.	Shape	Area (cm^2)	X_i (cm)	Y_i (cm)	$A_i X_i$	$A Y_i$
A1		A_1=1/2lb => 0.5×5.2× 12.2 => 31.72	X_1 = 2/3 × 12.2 => 8.133	Y_1 = 2/3 × 5.2 + 133.6 => 137.067	$A_1 X_1$ = 31.72 × 8.133 => 257.978	A_1Y_1=31. 72 × 137.067 => 4347.765
A2		A_2 = lb => 5.2×43.2 => 224.64	X_2= 0.5 × 43.2 + 12.2 => 33.8	Y_2 = 0.5×5.2 + 133.6 => 136.2	$A_2 X_2$= 224.64 × 33.8 => 7592.83	A_2Y_2= 136.2 × 224.64 => 30595.97
A3		A_3 = 1/2lb => 0.5 × 17.6 × 31.4 => 276.32	X_3= 2/3 × 17.6 + 55.4 => 67.133	Y_3= 2/3 × 31.4 +107.4 => 128.33	$A_3 X_3$ = 276.32 × 67.13 => 18549.36	A_3Y_3 = 128.33 × 276.32 => 35460.14
A4		A_4 = 1/2bh => 0.5 × 17.6 × 31.4 => 276.32	X_4= 1/3 × 17.6 +73 => 78.867	Y_4= 2/3 × 31.4 + 107.4 => 128.33	$A_4 X_4$ = 276.32 × 78.867 => 21792.53	A_4Y_4= 276.32 × 128.33 => 35460.14

A5		A_5 =1/2bh => 0.5 × 17.6 × 32.2 => 283.36	X_5= 2/3 × 17.6 + 55.4 => 67.133	Y_5= 1/3 × 32.2 + 75.2 => 85.933	A_5 X_5= 283.36 × 67.133 => 19022.81	A_5Y_5= 283.36 × 85.933 => 24349.97
A6		A_6=1/2bh => 0.5 × 17.6 × 32.2 => 283.36	X_6= 1/3 × 17.6 +73 => 78.867	Y_6= 1/3 × 32.2 + 75.2 => 85.933	A_6 X_6 = 283.36 × 78.867 => 22347.75	A_6Y_6= 283.36 × 85.933 => 24349.97
A7		$A_7=\pi r^2$ => 3.14 × 9.1 × 9.1 => 260.23	X_7= 9.1+ 63.9 => 73	Y_7= 9.1 + 144 => 153.1	A_7 X_7= 260.23 × 73 => 18996.79	A_7Y_7= 260.23× 153.1 => 39841.21
A8		A_8 =lb => 6.2 × 5.2 => 32.24	X_8=0.5 × 6.2 + 69.9 => 73	Y_8= 0.5 × 5.2 + 138.8 => 141.4	A_8X_8= 32.24 × 73 => 2353.52	A_8Y_8= 32.24 × 141.4 => 4558.74

A9		A_9=lb => 43.2×5.2 => 224.64	$X_9 = 0.5 \times 43.2 + 90.6$ => 112.2	$Y_9 = 0.5 \times 5.2 + 133.6$ => 136.2	$A_9 X_9 = 224.64 \times 112.2$ => 25204.61	$A_9 Y_9 = 224.64 \times 136.2$ => 30595.97
A10		A_{10}=1/2bh => $0.5 \times 12.2 \times 5.2$ => 31.72	$X_{10} = 1/3 \times 12.2 + 133.8$ => 137.867	$Y_{10} = 2/3 \times 5.2 + 133.6$ => 137.067	$A_{10} X_{10} = 31.72 \times 137.867$ => 4373.14	$A_{10} Y_{10} = 31.72 \times 137.067$ => 4347.76
A11		A_{11}=1/2bh => $0.5 \times 7.6 \times 75.2$ => 285.76	$X_{11} = 2/3 \times 7.6 + 55.4$ => 60.467	$Y_{11} = 2/3 \times 75.2$ => 50.133	$A_{11} X_{11} = 285.76 \times 60.467$ => 17279.05	$A_{11} Y_{11} = 285.76 \times 50.133$ => 14326.01
A12		A_{12}= 1/2bh => $0.5 \times 7.6 \times 75.2$ => 285.76	$X_{12} = 1/3 \times 7.6 + 63$ => 77.733	$Y_{12} = 2/3 \times 75.2$ => 50.13	$A_{12} X_{13} = 285.76 \times 77.733$ => 22212.98	$A_{12} Y_{12} = 285.76 \times 50.13$ => 14326.01
A13		A_{13} = 1/2bh => $0.5 \times 7.6 \times 75.2$ => 285.76	$X_{13} = 2/3 \times 7.6 + 75.4$ => 80.467	$Y_{13} = 2/3 \times 75.2$ => 50.13	$A_{13} X_{13} = 285.76 \times 80.467$ => 22994.25	$A_{13} Y_{13} = 285.76 \times 50.13$ => 14326.01

A14		A_{14}= 1/2bh => 0.5 × 7.6 × 75.2 => 285.76	X_{14} = 1/3 × 7.6 + 83 => 85.533	Y_{14} = 2/3 × 75.2 => 50.13	A_{14} X_{14} = 285.76 × 85.533 => 24441.91	$A_{14}Y_{14}$= 285.76 × 50.13 => 14326.01

total area of the given human body is:

A= $A_1 + A_2 + A_3 + A_4 + A_5 + A_6 + A_7 + A_8 + A_9 + A_{10} + A_{11} + A_{12} + A_{13} + A_{14}$

- ⇨ 31.72 + 224.64 + 276.32 + 276.32 + 283.36 + 283.36 + 260.23 + 32.24 + 224.64 + 31.72 + 285.76 + 285.76+ 285.76+ 285.76
- ⇨ 3067.59 cm^2

Now,

$$\bar{X} = \frac{\sum_{i-1}^{14} \text{Ai Xi}}{A}$$

⇨ $$\frac{A_1X_1+A_2X_2+A_3X_3+A_4X_4+A_5X_5+A_6X_6+A_7X_7+A_8X_8+A_9X_9+A_{10}X_{10}+A_{11}X_{11}+A_{12}X_{12}+A_{13}X_{13}+A_{14}X_{14}}{A}$$

⇨ $$\frac{257.978 +7592.83+18549.36+21792.53 +19022.81 +22347.75 +18996.79 +2353.52+25204.61+4373.14+17279.05+22212.98+ 22994.25+24441.91}{3067.59}$$

⇨ 74.136 cm

$$\bar{Y} = \frac{\sum_{i-1}^{14} \text{Ai Yi}}{A}$$

⇨ $$\frac{4347.765 +30595.97+35460.14 +35460.14 +24349.97 +24349.97 +39841.21 +4558.74+30595.97 +4347.76+14326.01 +14326.01 + 14326.01+14326.01}{3067.59}$$

⇨ 94.9317 cm

Solution to Question No. B4:

5.1 Overview:

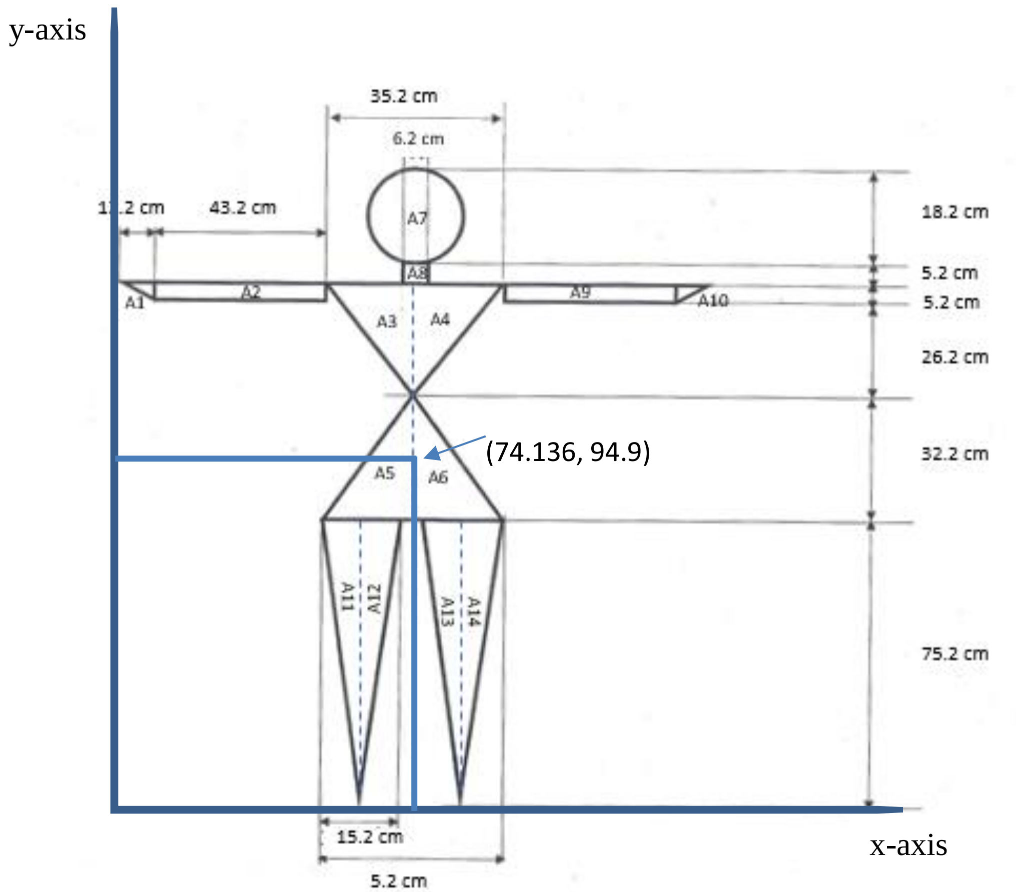


Fig 4.1 FBD by showing the place of centroid