Distributed Loads

Decimals have a point.

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Distributed Loads

- Up to this point, all the forces we have considered have been point loads
- Single forces which are represented by a vector
- Not all loading conditions are of that type

Distributed Loads

- Consider how your ears feel as you go deeper into a swimming pool.
- The deeper you go, the greater the pressure on your ears.

Distributed Loads

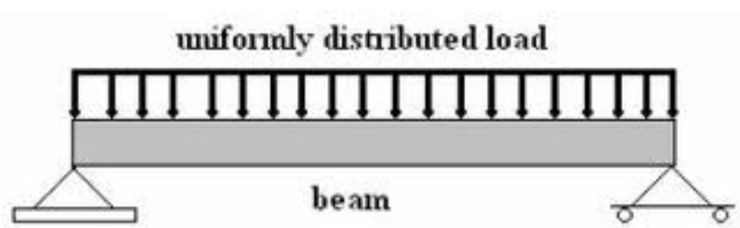
- If we consider how this pressure acts on the walls of the pool, we would have to consider a force (generated by the pressure) that was small at the top and increased as we went down.

Distributed Loads

- This is known as a distributed force or a distributed load.
- It is represented by a series of vectors which are connected at their tails.

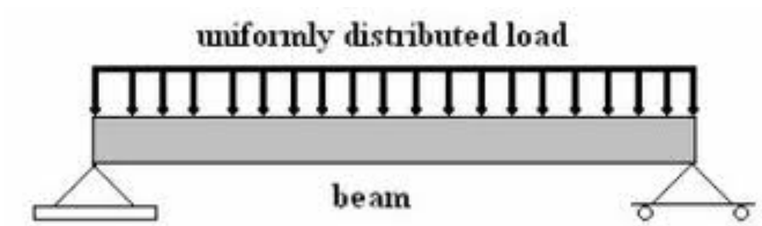
Distributed Loads

- One type of distributed load is a uniformly distributed load



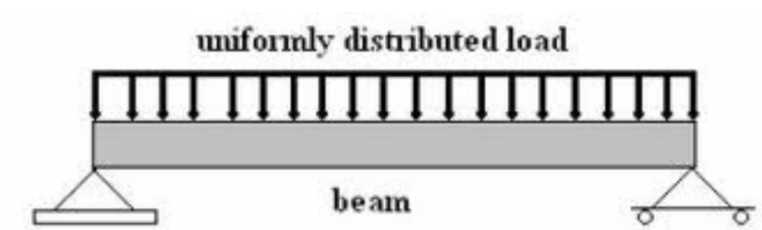
Distributed Loads

- This load has the same intensity along its application.
- The intensity is given in terms of Force/Length



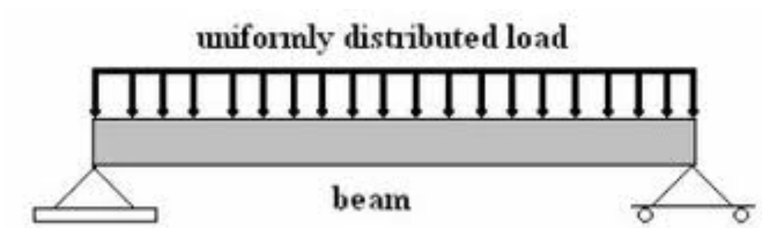
Distributed Loads

- The total magnitude of this load is the area under the loading diagram.
- So here it would be the load intensity time the beam length.



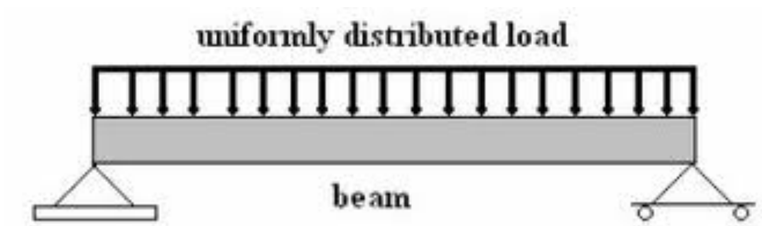
Distributed Loads

- If, for analysis purposes, we wanted to replace this distributed load with a point load, the location of the point load would be in the center of the rectangle.



Distributed Loads

- We do this to solve for reactions.
- For a uniform load, the magnitude of the equivalent point load is equal to the area of the loading diagram and the location of the point load is at the center of the loading diagram.



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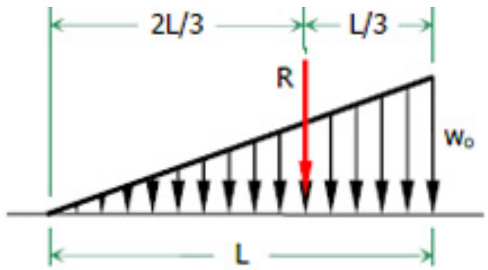
Distributed Loads

- A second type of loading we often encounter is a triangular load



Triangular Load

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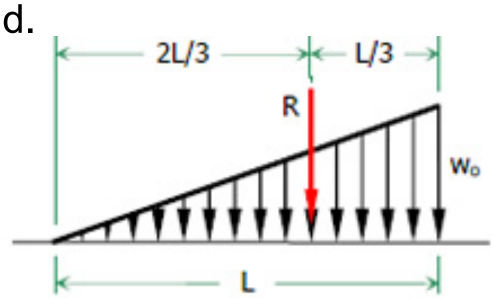
Distributed Loads

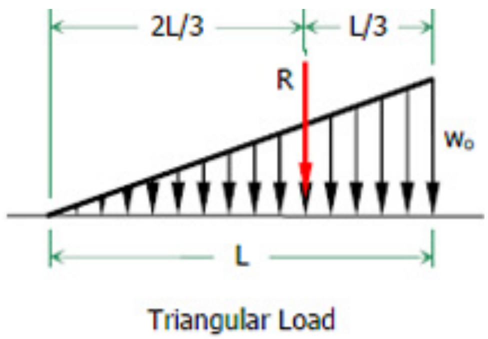
- A triangular load has an intensity of 0 at one end and increases to some maximum at the other end.



Triangular Load

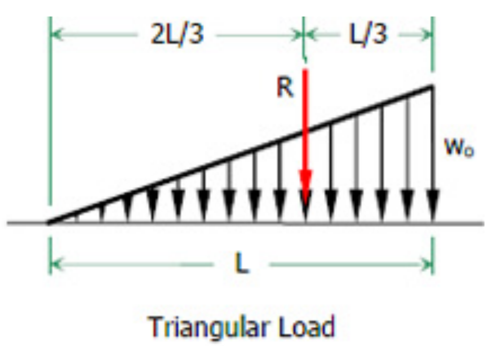
Distributed Loads

- You will often see the intensity represented with the letter w.



Distributed Loads

- The magnitude of an equivalent point load will again be the area under the loading diagram.



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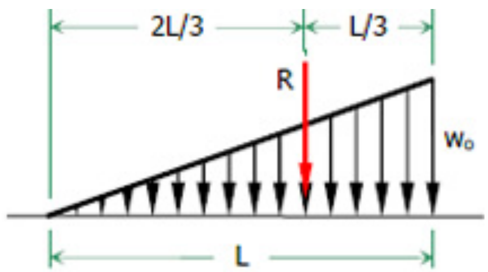
Distributed Loads

- For a triangle, this would be ½ the base times the maximum intensity.



Triangular Load

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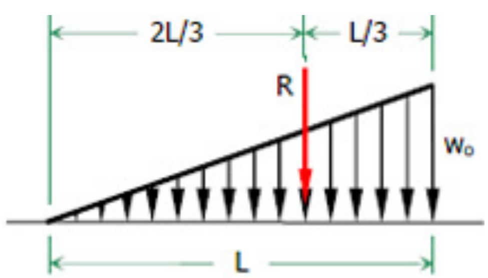
Distributed Loads

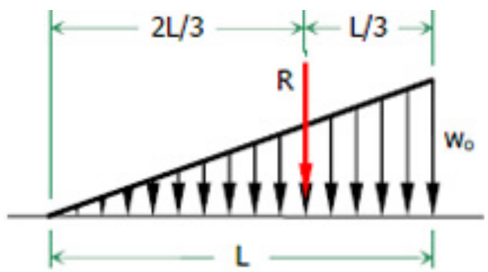
- The location of the equivalent point load will be 2/3 of the distance from the smallest value in the loading diagram.



Triangular Load

Distributed Loads

- There are other types of loading diagrams but these will be sufficient for now.



Triangular Load

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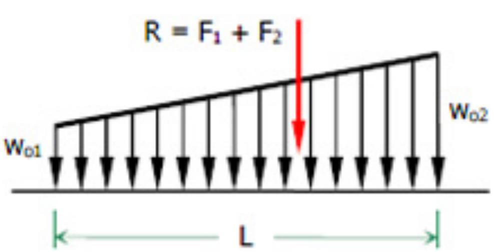
Distributed Loads

- You may see a diagram that appears to be a trapezoidal loading.



Trapezoidal Load

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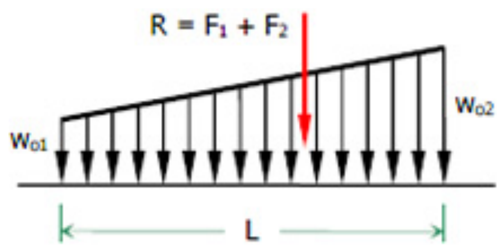
Distributed Loads

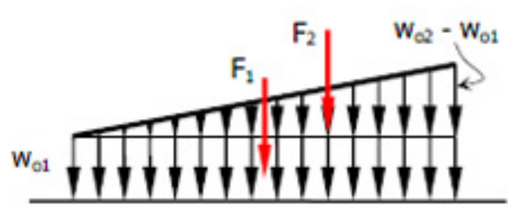
- In this case, we can divide the loading diagram into two parts, one a rectangular load and the other a triangular load.



Trapezoidal Load

Distributed Loads

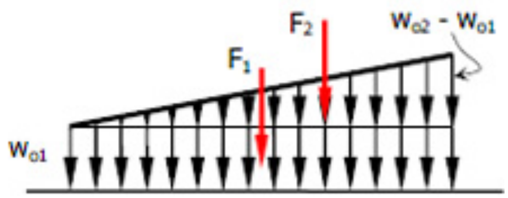
- Now you have two loads that you already have the rules for.



Resolution of trapezoidal load into rectangular and triangular loads

Distributed Loads

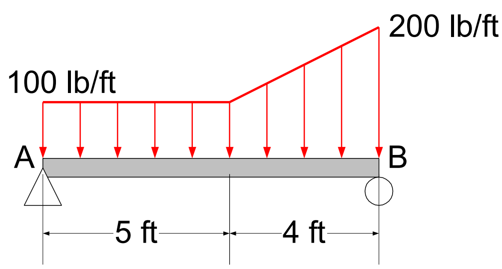
- Take care to note that the maximum intensity of the triangular load is now reduced by the magnitude of the rectangular load.



Resolution of trapezoidal load into rectangular and triangular loads

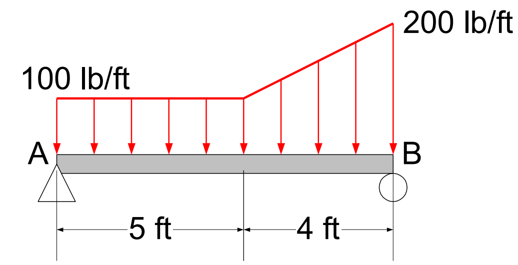
Example Problem

- Given: The loading and support as shown
- Required: Reactions at the supports



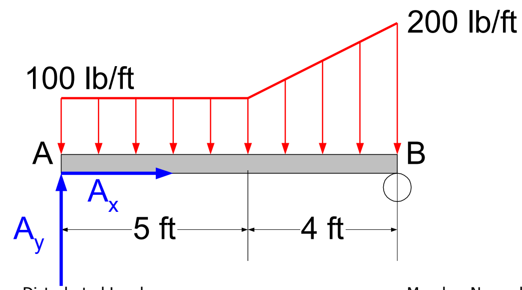
Example Problem

- Isolate the selected system from all connections
- Start with the pin at A



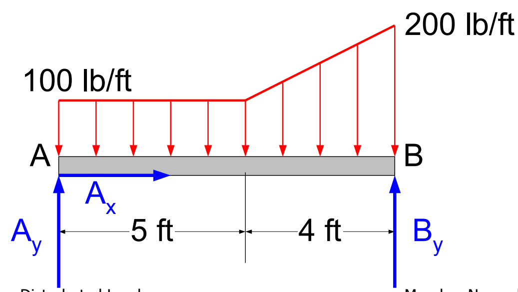
Example Problem

- We have a pin, so we have an x and a y component of the reaction and we will assume that both of them are +



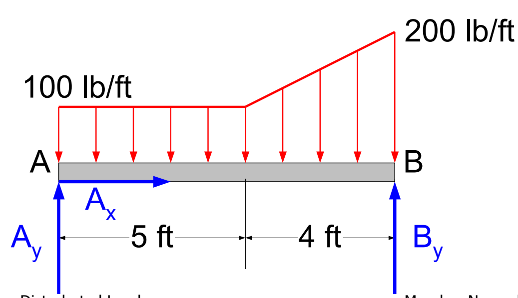
Example Problem

- Now we can remove the roller support at B recognizing that the direction of the reaction is +y



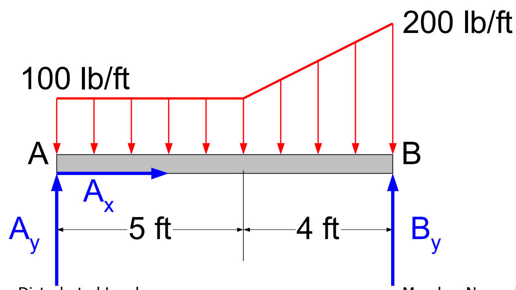
Example Problem

- We now have all the reactions identified and can proceed with the analysis



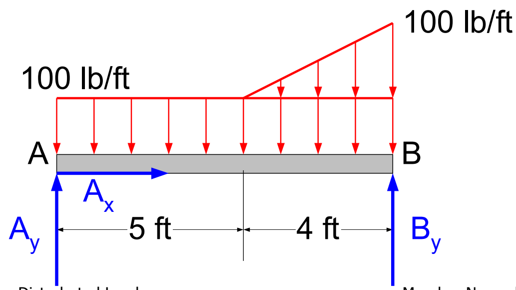
Example Problem

- The best idea is to now convert all distributed loads into point loads



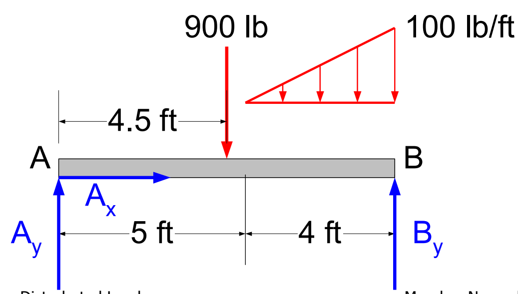
Example Problem

- Break the load into a rectangular load and a triangular load



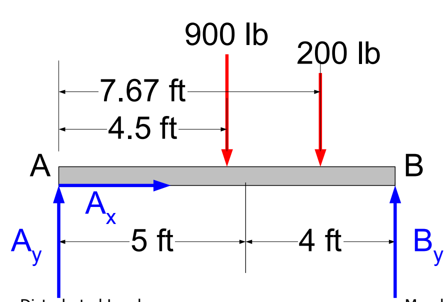
Example Problem

- For the rectangular load



Example Problem

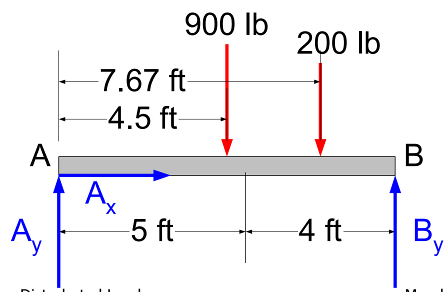
- For the triangular load



Example Problem

- We have three unknowns, A_y, A_x, and B_y
- Luckily we have three equilibrium constraints to solve for them

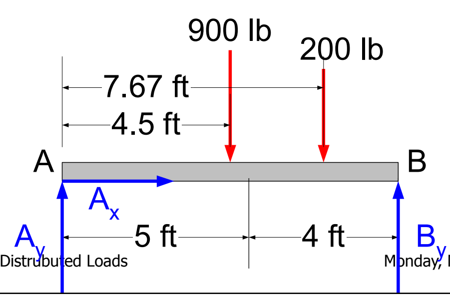
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$



Example Problem

- Summing the moments about A to solve for B_y.

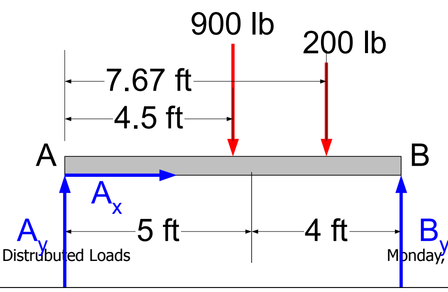
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$



Example Problem

- Writing the expression for the sum of the moments around A

$$\sum M = 0 = -(4.5ft)(900lb) - (7.67ft)(200lb) + (9ft)(B_y)$$



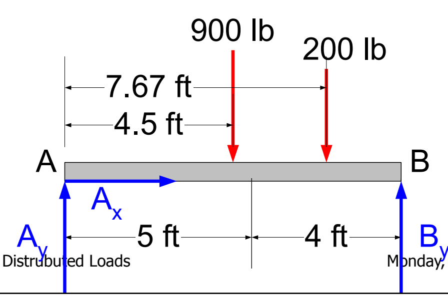
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$

Example Problem

- Isolating and solving for B_y

$$\frac{(4.5ft)(900lb) + (7.67ft)(200lb)}{(9ft)} = B_y$$

$$620.37lb = B_y$$



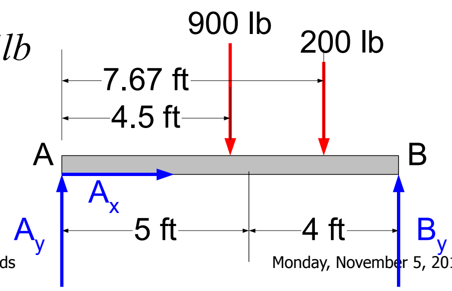
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$

Example Problem

- Sum of the forces in the y-direction

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$

$$\sum F_y = 0 = A_y - 900lb - 200lb + B_y$$
$$0 = A_y - 900lb - 200lb + 620.37lb$$
$$A_y = +900lb + 200lb - 620.37lb$$
$$A_y = 479.63lb$$

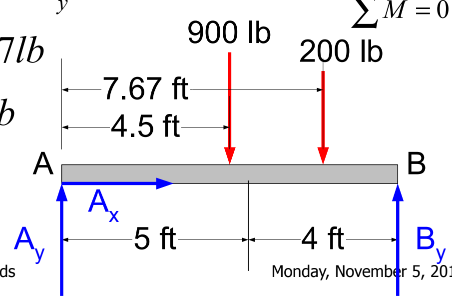


Example Problem

- Since the magnitude of our solution came out positive, we assumed the correct direction

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$

$$\sum F_y = 0 = A_y - 900lb - 200lb + B_y$$
$$0 = A_y - 900lb - 200lb + 620.37lb$$
$$A_y = +900lb + 200lb - 620.37lb$$
$$A_y = 479.63lb$$

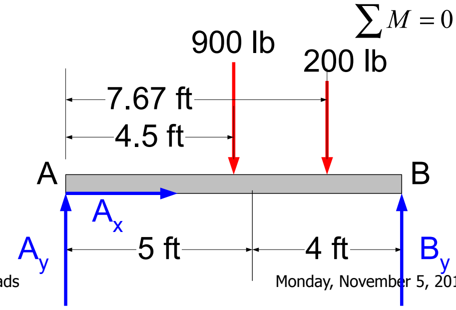


Example Problem

- Now our final constraint condition

$$\sum F_x = 0 = A_x$$
$$0 = A_x$$
$$A_x = 0lb$$

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$

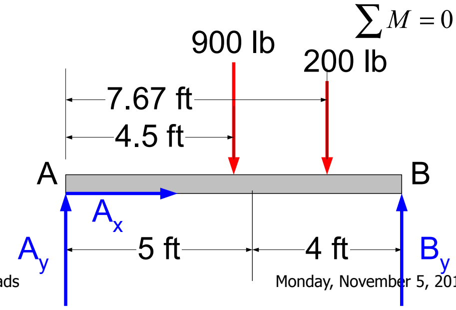


Example Problem

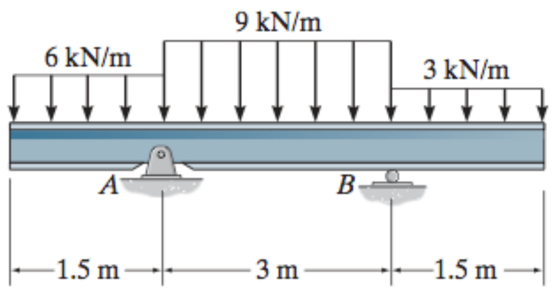
- So our complete solution to the problem is

$$A_x = 0lb$$
$$A_y = 479.63lb$$
$$B_y = 620.37lb$$

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M = 0$$

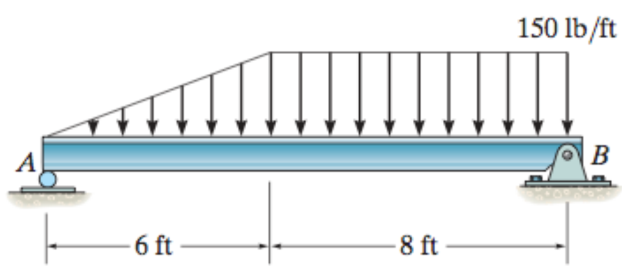


F4–37. Determine the resultant force and specify where it acts on the beam measured from *A*.



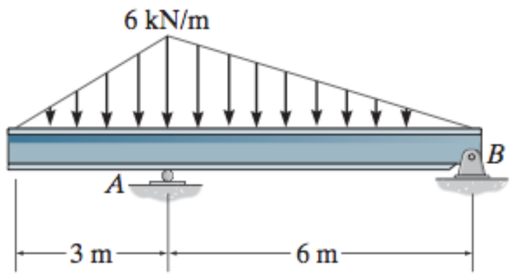
F4–37

F4–38. Determine the resultant force and specify where it acts on the beam measured from *A*.



F4–38

F4–39. Determine the resultant force and specify where it acts on the beam measured from A.



F4–39

Homework

- Problem 4-145
- Problem 4-148
- Problem 4-153