MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

National aerospace university “Kharkiv Aviation Institute”

Department of aircraft strength

Course
Mechanics of materials and structures

HOME PROBLEM 2

Graphs of Normal Force Distribution in Tension-Compression

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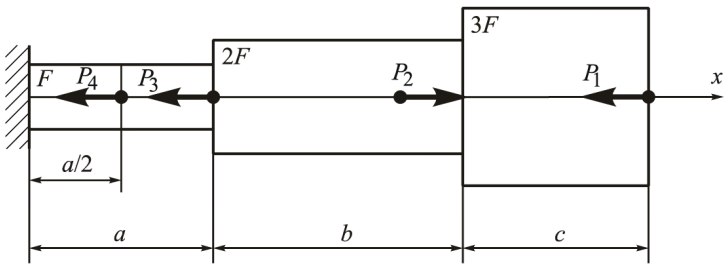
National aerospace university
"Kharkiv Aviation Institute"
Department of aircraft strength

Subject: mechanics of materials
Document: home problem
Topic: graphs of normal force distribution in tension-compression of a rod

Full name of the student, group

Variant: 1 **Complexity: 1**



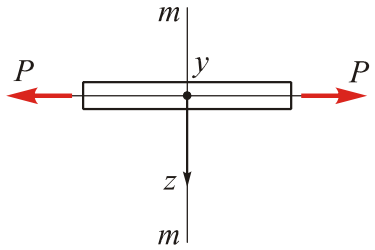
Given: $P_1 = 20$ kN, $P_2 = 40$ kN, $P_3 = 100$ kN, $P_3 = 80$ kN
$a = 3$ m, $b = 4$ m, $c = 5$ m.

Goal: obtain equations of normal force in cross-sections of a rod and draw the graphs of its distribution along the length of a rod.

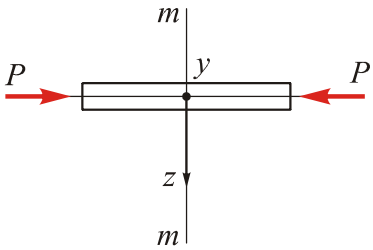
Full name of the lecturer **signature**

Mark:

In calculating the normal force in the rod cross-sections, we will use the rule that the normal force in the cross-section is numerically equal to algebraic sum of external forces applied to the right or to the left part of the rod. Tensile external force should be substituted into the equation of normal force with positive sign and visa versa. This sign convention is shown on Fig. 1.



$N_x^{m-m} > 0$



$N_x^{m-m} < 0$

Fig. 1

Solution

1. Selecting the arbitrary cross-sections at x-distances from the origin of each potion.
In this solution, we will consider the equilibrium of right-situated parts of the rod to exclude preliminary calculating the support reaction (see Fig. 2).
2. Writing the equations of normal force in an arbitrary cross-sections of each potion.

I – I $(0 < x < c)$:

$$N_x^I(x) = -P_1 = -20 \text{ kN}.$$

II – II $(0 < x < b)$:

$$N_x^{II}(x) = -P_1 + P_2 = -20 + 40 = 20 \text{ kN}.$$

III – III $(0 < x < a/2)$:

$$N_x^{III}(x) = -P_1 + P_2 - P_3 = -20 + 40 - 100 = -80 \text{ kN}.$$

IV – IV $(0 < x < a/2)$:

$$N_x^{IV}(x) = -P_1 + P_2 - P_3 - P_4 = -20 + 40 - 100 - 80 = -160 \text{ kN}.$$

3. Designing the graph of normal force distribution (see Fig. 2).

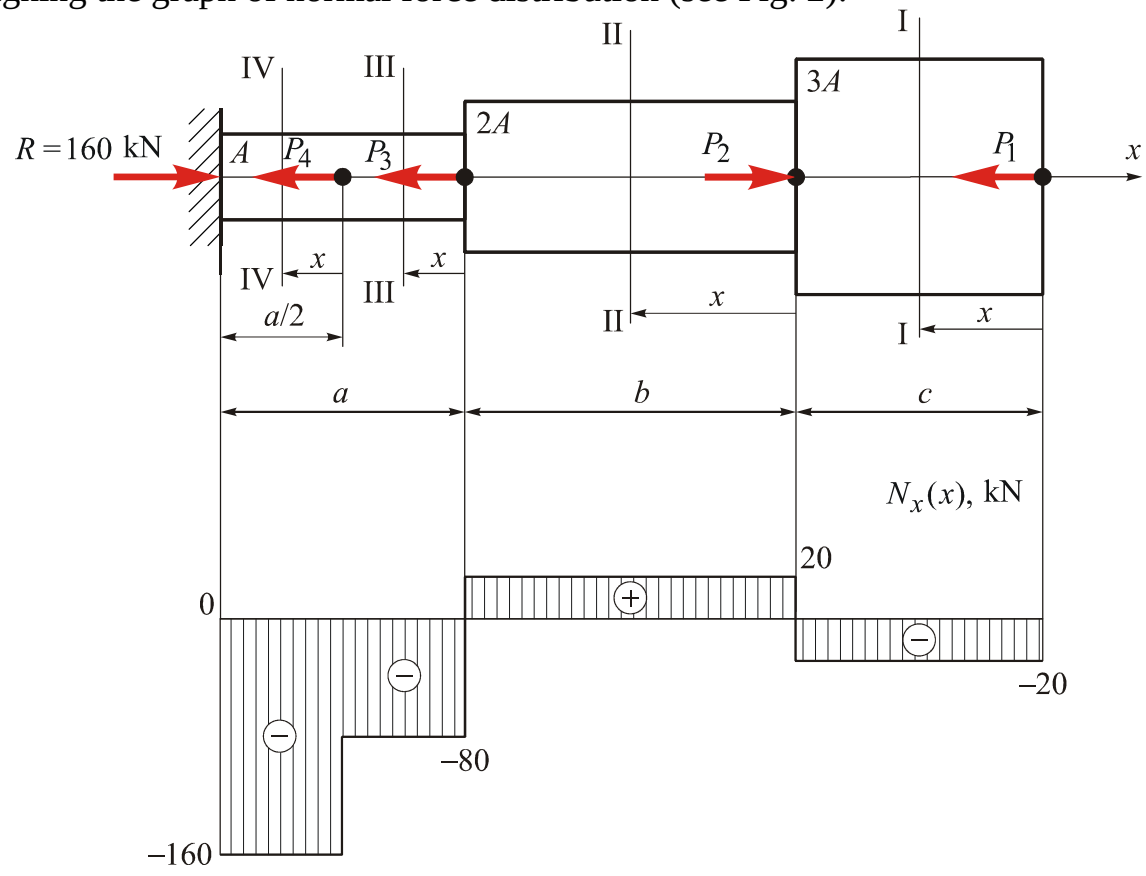


Fig. 2

4. Determining the reaction in support using the graph of normal force distribution.
It is clear from Fig. 2 that in the last potion IV-IV normal force is -160 kN (compression). The balance of remaining part of the rod under the normal force $N_x^{IV} = -160$ kN from the right and the reaction R from the left shows that R must be equal in modulus to normal force, i.e. $R = 160$ kN and be directed to the right to create negative N_x^{IV}. This fact is shown on Fig. 2.