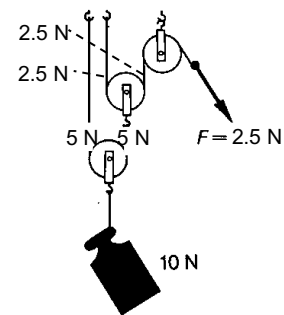


1. a) Fixed pulley: It merely changes the direction of the force while its magnitude remains the same:  $F = \underline{10\text{ N}}$
- b) Movable pulley: The weight of the load is divided between two pieces of rope, each one carrying half of the load's weight:  $F = \underline{5.0\text{ N}}$
- c) At the movable (lower) pulley, the load's weight is divided between two pieces of rope. The fixed pulley only changes the direction of the force, leaving its magnitude unchanged:  $F = \underline{5.0\text{ N}}$
- d) The weight of the load is divided among the four pieces of rope carrying the load:  $F = \underline{2.5\text{ N}}$
- e) The weight of the load is divided among three pieces of load-carrying rope:  $F = \underline{3.3\text{ N}}$
- f) The weight of the load is divided among four pieces of load-carrying rope:  $F = \underline{2.5\text{ N}}$
- g) The (lower) movable pulley divides the load's weight between two pieces of rope - thus, in each piece of rope, the force is 5.0 N. The piece of rope to the right is attached to another movable pulley which again divides the force between two pieces of rope: 2.5 N each (see picture). The fixed pulley changes the direction of the force, but not its magnitude:  $F = \underline{2.5\text{ N}}$



- h) The load is hanging from one single rope, the load's weight is not divided. The fixed pulleys only change the direction of the force, not its magnitude:  $F = \underline{100\text{ N}}$
- i) The load is hanging from one single rope, the load's weight is not divided. The fixed pulleys only change the direction of the force, not its magnitude:  $F = \underline{100\text{ N}}$
- j) The magnitude of the force in the rope is the same on either side, which is 100 N in each rope. Therefore, the force required on the right side is:  $F_2 = 100\text{ N} - 50\text{ N} = \underline{50\text{ N}}$
- k) The load's weight is divided among four pieces of rope:  $F = \underline{25\text{ N}}$
- l) The load's weight is divided among six pieces of rope:  $F = \underline{50\text{ N}}$

2. a) The fixed pulley changes the direction of the force but not its magnitude. The force in ① is the same as in ③, 15 N each. In ②, the forces of both pieces of rope, ① and ③, as well as the weight of the fixed pulley, add up:  $F = 15 \text{ N} + 15 \text{ N} + 4.0 \text{ N} = \underline{34 \text{ N}}$ .
- b) The load's weight is the sum of the weight of the box and the weight of the movable pulley:  $F_G = 16 \text{ N} + 4.0 \text{ N} = 20 \text{ N}$ . The load's weight is divided between the two pieces of rope ① and ②:  $F = 20 \text{ N} : 2 = \underline{10 \text{ N}}$  each.
- c) The load's weight is the sum of the weight of the box and the weight of the movable pulley:  $F_G = 17 \text{ N} + 3.0 \text{ N} = 20 \text{ N}$ . The load's weight is divided between the two pieces of rope ③ and ④:  $F = 20 \text{ N} : 2 = 10 \text{ N}$  each. The fixed pulley merely changes the direction of the force (while the magnitude of the force remains unchanged). The force in the piece of rope at ① is the same as in ③: 10 N. In ②, the forces of both pieces of rope, ① and ③, as well as the weight of the fixed pulley, add up:  $F = 10 \text{ N} + 10 \text{ N} + 3.0 \text{ N} = \underline{23 \text{ N}}$
- d) The load's weight is the sum of the weight of the box and the weight of the movable pulleys:  $F_G = 18 \text{ N} + 2.0 \text{ N} + 2.0 \text{ N} = 22 \text{ N}$ . The load's weight is divided among the four pieces of rope ①, ②, ④ and ⑤:  $F = 22 \text{ N} : 4 = 5.5 \text{ N}$  each. In ③, the forces of both pieces of rope, ② and ④, as well as the weight of the fixed pulley, add up:  $F = 5.5 \text{ N} + 5.5 \text{ N} + 2.0 \text{ N} = \underline{13 \text{ N}}$
3. a) The load's weight is the sum of the weight of the box and the weight of the movable pulley:  $F_G(\text{load}) = 5'000 \text{ N} + 70.00 \text{ N} = 5'070 \text{ N}$ . The load's weight is divided among three pieces of rope:  $F_{\text{pull}} = F_G(\text{load}) : 3 = 5'070 \text{ N} : 3 = \underline{1'690 \text{ N}}$
- b) One third of the force  $\rightarrow$  Threefold distance:  $3 \cdot 15.0 \text{ m} = \underline{45.0 \text{ m}}$
- c) In A, the forces of four pieces of rope ( $4 \cdot 1'690 \text{ N} = 6'760 \text{ N}$ ), as well as the weight of both fixed pulleys ( $2 \cdot 200 \text{ N} = 400 \text{ N}$ ), add up:  $F = 6'760 \text{ N} + 400 \text{ N} = \underline{7'160 \text{ N}}$
4. The load's weight is the sum of the weight of the box and the weight of the movable pulley:  $F_G(\text{load}) = 3'400 \text{ N} + 110.0 \text{ N} = 3'510 \text{ N}$ . The load's weight is divided among three pieces of rope:  $F_{\text{pull}} = F_G(\text{load}) : 3 = 3'510 \text{ N} : 3 = 1'170 \text{ N}$ .
- The work done on the rope is  $W_{\text{rope}} = F_{\text{rope}} \cdot s_{\text{rope}}$ , thus  $s_{\text{rope}} = \frac{W_{\text{rope}}}{F_{\text{rope}}} = \frac{5'890 \text{ J}}{1'170 \text{ N}} = 5.03 \text{ m}$
- Threefold force  $\rightarrow$  one third of the distance:  $5.03 \text{ m} : 3 = \underline{1.68 \text{ m}}$
- Or: from  $W_{\text{rope}} = F_{\text{rope}} \cdot s_{\text{rope}} = W_{\text{load}} = F_{\text{load}} \cdot s_{\text{load}}$  we get  $s_{\text{load}} = \frac{W_{\text{load}}}{F_{\text{load}}} = \frac{5'890 \text{ J}}{3'510 \text{ N}} = \underline{1.68 \text{ m}}$