**Answer on** Question #57786, Physics / Mechanics | Relativity

A sailor pushes a 100.0 kg crate up a ramp that is 3.00 m high and 5.00 m long onto the deck of a ship. He exerts a 650.0 N force parallel to the ramp. What is the mechanical advantage of the ramp? What is the efficiency of the ramp? Your response should include all of your work and a free-body diagram.

**Find:** ΔF – ? η – ?

**Given:**

m=100 kg

h=3 m

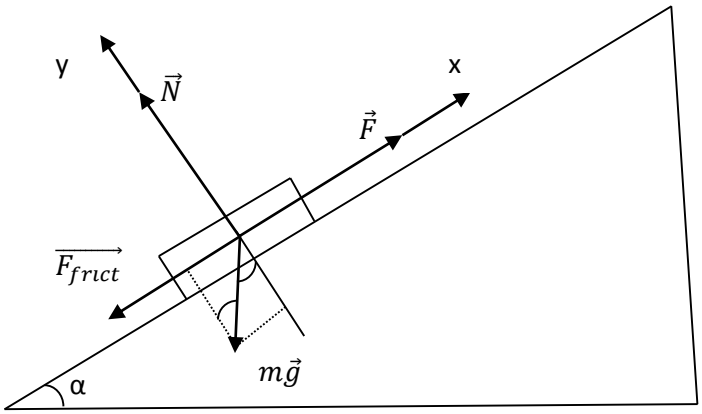
l=5 m

F=650 N

g=9,8 N/kg

**Solution:**

Consider the forces, which acting on the crate.




Newton's Second Law:

$\sum_{i=1}^{n} \overrightarrow{F_i} = m\vec{a}$ (1)

We believe that the body moves in straight lines and uniformly.

Because $\vec{a} = \vec{0}$ (2)

Write the vector sum of all forces:

$\sum_{i=1}^{n} \overrightarrow{F_i} = \vec{F} + \overrightarrow{F_{frict}} + \vec{N} + m\vec{g}$ (3),

where $\vec{F}$ –traction force,

$\overrightarrow{F_{frict}}$ – friction force,

$\vec{N}$ – reaction force,

$m\vec{g}$ – gravity

(2) and (3) in (1):

$\vec{F} + \overrightarrow{F_{frict}} + \vec{N} + m\vec{g} = \vec{0}$ (4)

Find the projection of forces.

OX: $F - F_{frict} - mg\sin\alpha = 0$ (5)

OY: $N - mg\cos\alpha = 0$ (6)

Friction force (with a particular approach):

$F_{frict} = \mu N$ (7),

where μ – coefficient of friction ($\mu < 1$)

Of (6) $\Rightarrow$ $N = mg\cos\alpha$ (8)

(8) in (7): $F_{frict} = \mu mg\cos\alpha$ (9)

Of (5) $\Rightarrow$ $F = F_{frict} + mg\sin\alpha$ (10)

(9) in (10): $F = mg(\mu\cos\alpha + \sin\alpha)$ (11)

Expression $(\mu\cos\alpha + \sin\alpha) < 1$ (12)

Of (11) and (12) $\Rightarrow$ $F = mg(\mu\cos\alpha + \sin\alpha) < mg$ (13)

Of (13) $\Rightarrow$ mechanical advantage of the ramp:

$\Delta F = mg - F$ (14)

Of $\Rightarrow$ ΔF=330 N

Efficiency of the ramp:

$\eta = \frac{A_{helpful}}{A_{spent}} \times 100\%$ (15),

where $A_{helpful}$ – helpful work,

$A_{spent}$ – spent work

Helpful work: $A_{helpful} = mgh$ (16),

Spent work: $A_{spent} = Fl$ (17)

(16) and (17) in (15):

$\eta = \frac{mgh}{Fl} \times 100\%$ (18)

Of (18) $\Rightarrow$ $\eta = 90\%$

**Answer:**

ΔF=330 N

η=90%