Harold's Physics
Forces with FBD
Cheat Sheet

13 October 2026

Forces on a Pulled Box

Question

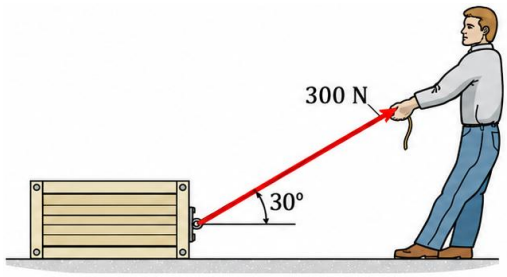
A man pulls a 50 kg box with a force of 300 N. As the box slides to the right on a horizontal floor and remains in contact with it, it experiences an opposing frictional force. As a result of the forces acting on it, the box accelerates to the right at 4.0 m/s².

Diagram:

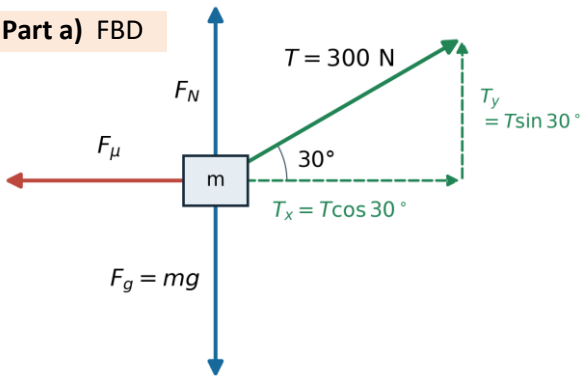
- The pulling force is directed at **30° above the horizontal**.
- The positive x-axis points right, and the positive y-axis points upward.

a) Draw the free-body diagram (FBD) of the box.
b) Calculate the net force ($\boldsymbol{F}_{net}$) acting on the box.
c) Write the equation expressing Newton's Second Law for the x-components of the forces acting on the box and use it to calculate the force of friction (F_μ) acting on the box.
d) Write the equation expressing Newton's Second Law for the y-components of the forces acting on the box and use it to calculate the normal force (F_N) acting on the box.
e) Calculate the coefficient of kinetic friction (μ_k) for the box on the floor.

Diagrams



Part a) FBD



Dashed green arrows represent components of ***T***, not additional forces. Diagram not to scale.

FBD Procedure

Identify the object, draw only external forces, choose axes, resolve components, and apply $\sum \boldsymbol{F_x} = m\boldsymbol{a_x}$, $\sum \boldsymbol{F_y} = m\boldsymbol{a_y}$.

Givens

$m = 50\ kg$
$\boldsymbol{T} = 300\ N$
$\theta = 30^{\circ}$ inclined from the horizontal
$\boldsymbol{a} = 4.0\ \frac{m}{s^2}\ to\ the\ right$

$\mu_k > 0$

Observations

$\boldsymbol{a_x} = \boldsymbol{a}$
$\boldsymbol{a_y} = 0$
$g = 9.81\ \frac{m}{s^2}$

$0 \leq F_{\mu_s} \leq \mu_s F_N$
$F_\mu = F_{\mu_k} = \mu_k F_N$

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Part b)	Calculate the net force ($\boldsymbol{F_{net}}$) acting on the box.
Equation	$$\boldsymbol{F_{net} = ma}$$
Solution	$$= (50\ kg)\left(4.0\ \frac{m}{s^2}\right)$$ $$\boldsymbol{F_{net} = 200\ N\ right}$$
Part c)	Write the equation expressing Newton's Second Law for the **x-components** of the forces acting on the box and use it to calculate the force of friction ($\boldsymbol{F_{\mu_k}}$) acting on the box.
Equation	$$\boldsymbol{F_{net,x} = \sum F_x = ma_x = T_x - F_{\mu_k}}$$
Solution	$$\boldsymbol{F_{\mu_k} = T_x - F_{net,x}}$$ $$\boldsymbol{F_{\mu_k} = T}\ cos\ 30° - \boldsymbol{F_{net,x}}$$ $$= (300\ N)\ cos\ 30° - 200\ N$$ $$= 259.8\ N - 200\ N$$ $$\boldsymbol{F_{\mu_k} = 59.8\ N\ left}$$
Part d)	Write the equation expressing Newton's Second Law for the **y-components** of the forces acting on the box and use it to calculate the normal force ($\boldsymbol{F_N}$) acting on the box.
Equation	$$\sum \boldsymbol{F_y} = 0$$ $$\boldsymbol{F_N + T_y - F_g = 0}$$
Solution	$$\boldsymbol{F_N = F_g - T_y}$$ $$\boldsymbol{F_N} = (50\ kg)\left(9.81\frac{m}{s^2}\right) - (300\ N)\ sin\ 30°$$ $$= 490.5\ N - 150\ N = 340.5\ N$$ $$\boldsymbol{F_N \approx 340\ N\ upward}$$
Part e)	Calculate the coefficient of kinetic friction (μ_k) for the box on the floor.
Equation	$$F_\mu = \mu_k\ F_N$$
Solution	$$\mu_k = \frac{F_\mu}{F_N}$$ $$\mu_k = \frac{59.8076\ N}{340.5\ N} = 0.17565$$ $$\boldsymbol{\mu_k \approx 0.18}$$ *The coefficient of kinetic friction is dimensionless.*

Sources

- Young, Hugh D. and Freedman, Roger A. (2015). University Physics with Modern Physics, 14th Edition, Section 4.6, Free-Body Diagrams. https://www.amazon.com/University-Physics-Modern-14th/dp/0321973615
- Numerade (n.d.). QUESTION 3. https://www.numerade.com/ask/question/question-3-a-man-is-pulling-a-box-of-a-mass-of-50-kg-with-a-force-of-300-n-as-the-box-moves-across-the-surface-it-experiences-a-friction-force-as-a-result-of-the-forces-acting-on-it-the-box--57916/

Acknowledgements

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