Physics 211

Sections 1 & 70
Dr. Geoffrey Lovelace
Fall 2012
Lecture 12 (10/04/12)

Lecture 12 outline

- Announcements
- Homework followup
- Class participation tutorial: second law

Announcements

- Homework
  - Homework #6: due Thursday 11:59PM
- Reading: for Thursday: through Sec. 5.5
- Office hours
  - 4PM-5PM today in MH-601B

Today

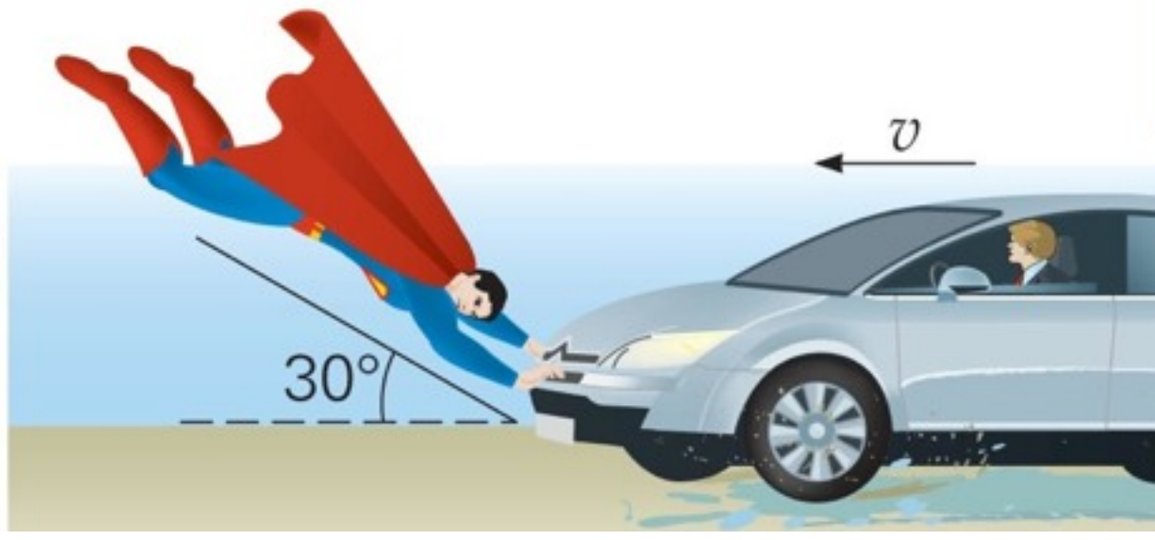
Sep 25	**Exam 1**
Sep 27	Laws of motion, *HW #4 due*
Oct 2	Free body diagrams
Oct 4	Free body diagrams, friction, *HW #5 due*
Oct 9	Work, introduction to energy
Oct 11	Energy, kinetic & potential energy, conservation of energy, *HW #6 due*
Oct 16	Conservation of energy
Oct 18	Linear momentum, conservation of linear momentum, *HW #7 due*
Oct 23	**Exam 2**
Oct 25	Conservation of momentum, collisions, *HW #8 due*
Oct 30	Collisions, center of mass, rockets
Nov 1	Circular motion, gravitation, *HW #9 due*
Nov 6	Gravitation, Kepler's laws, intro to rigid body rotation
Nov 8	Rotation, torque, angular momentum
Nov 13	Conservation of angular momentum *HW #10 due*
Nov 15	**Exam 3**
Nov 20	*Fall Recess — No class*
Nov 22	*Fall Recess — No class*
Nov 27	Temperature, gas laws
Nov 29	Phase changes, heat transfer, *HW #11 due*
Dec 4	Laws of thermodynamics, entropy
Dec 6	Harmonic motion, *HW #12 due*
Dec 11	Harmonic motion & waves
Dec 13	Gravitational waves, harmonic motion, black holes, *HW #13 due*
Dec 20	**Final exam 9:30AM–11:20AM**

Lecture 12 outline

- Announcements
- Homework & class participation followup
- Class participation tutorial: second law

Class participation #10

- 0. Name
- 1. Draw a free-body diagram for example from the textbook:
  - A car is sliding through a puddle. Superman arrives at the last moment and tries to stop the car. (Neglect friction.)
  - Hint: list **all** of the forces acting on the car. Then draw the diagram.



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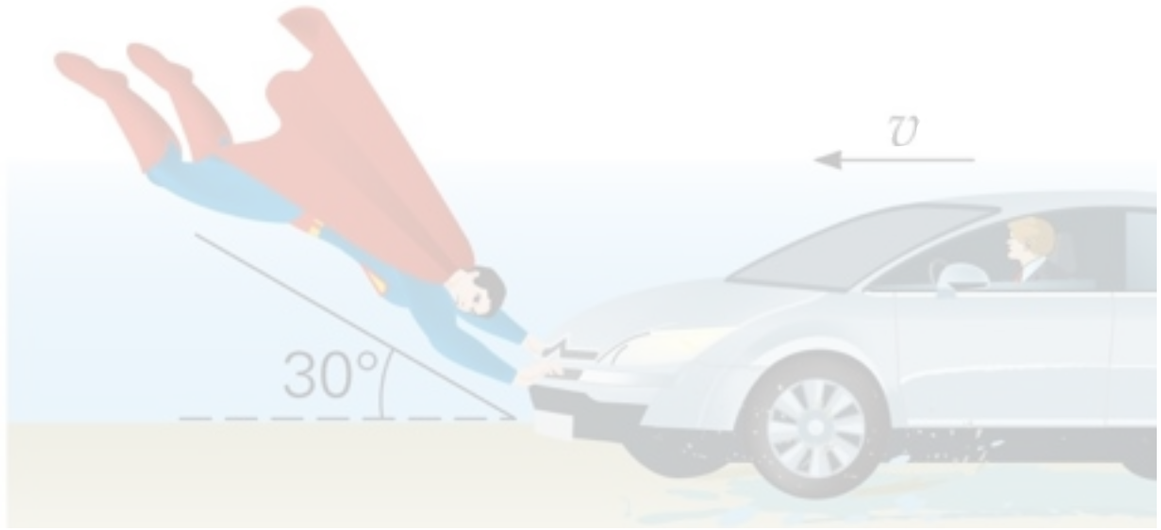

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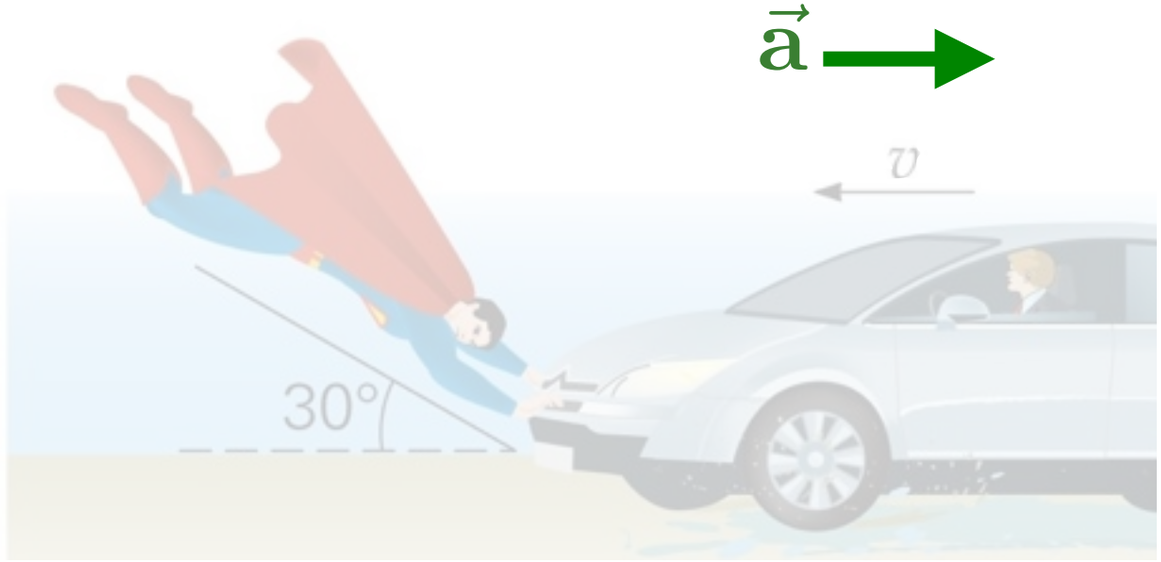

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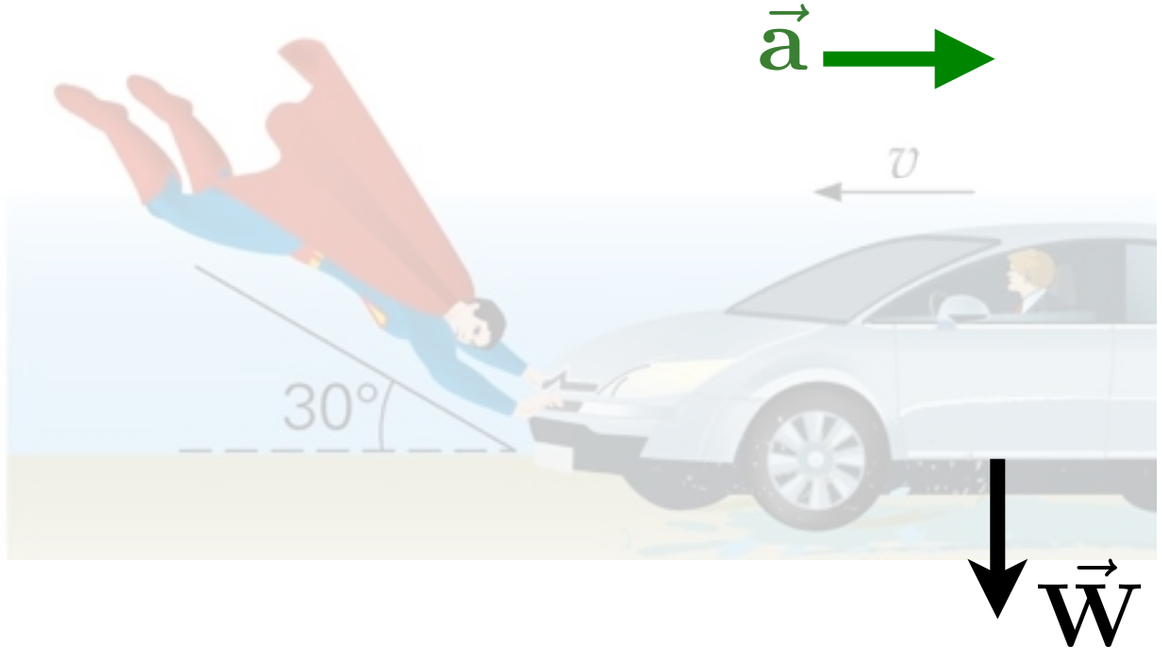

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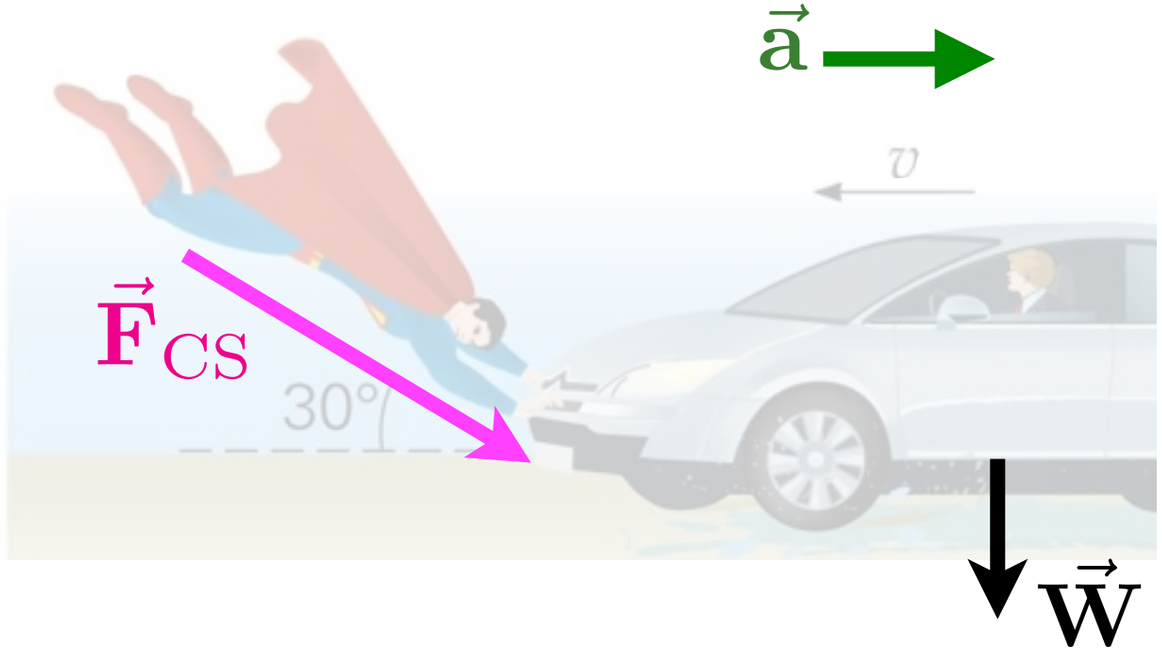

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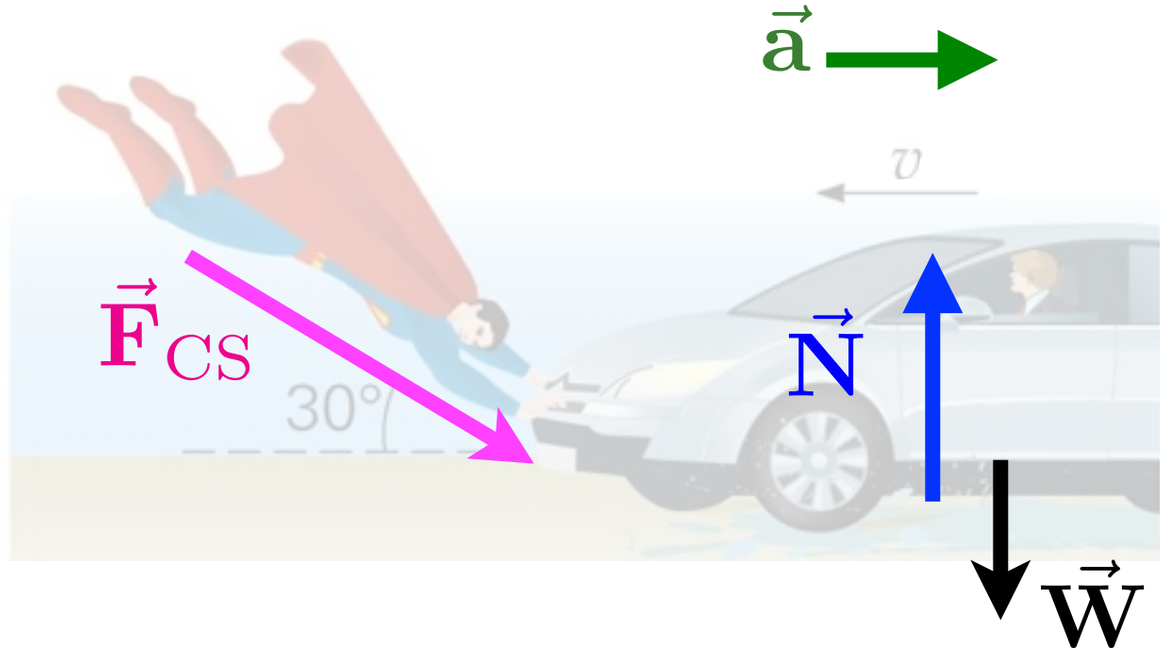

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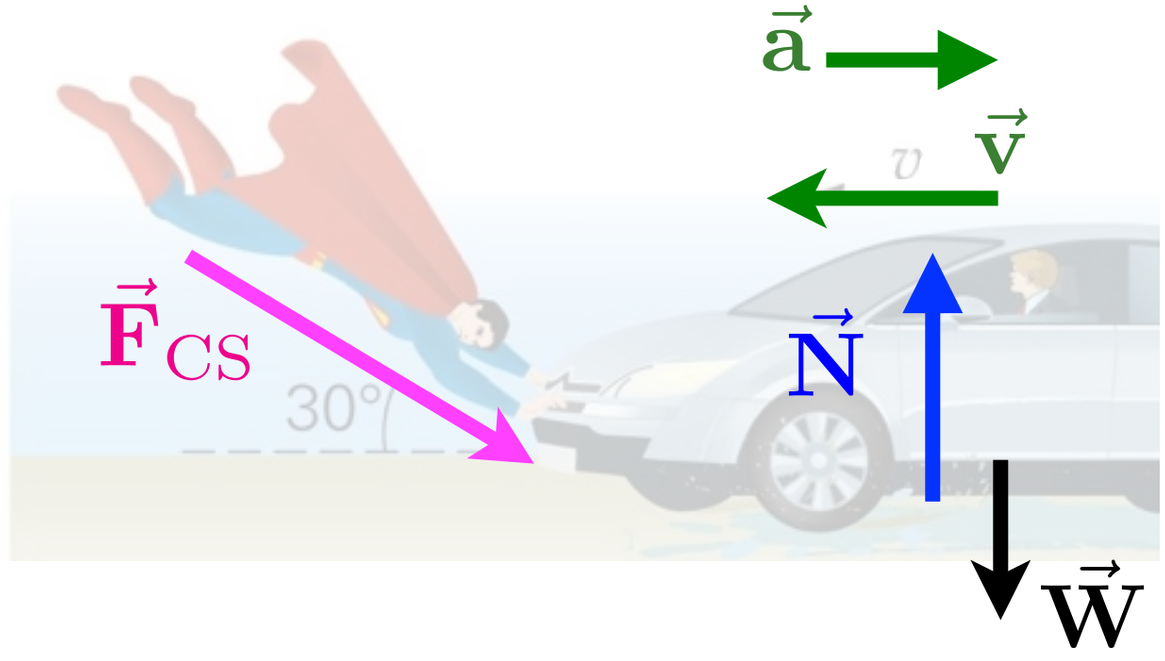

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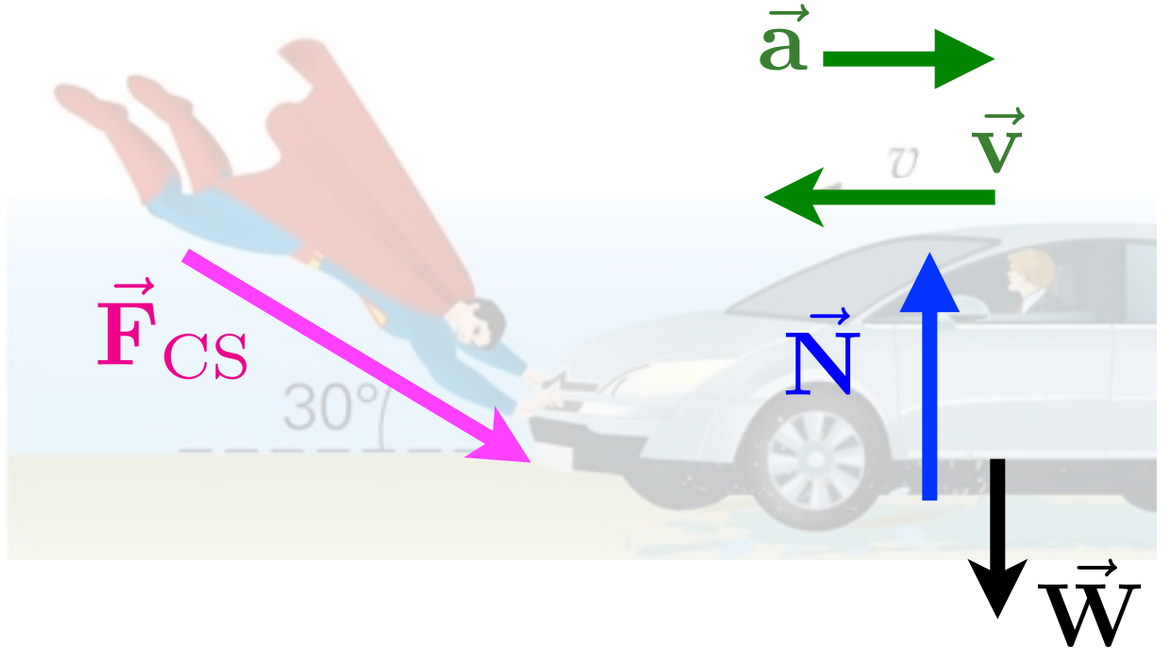

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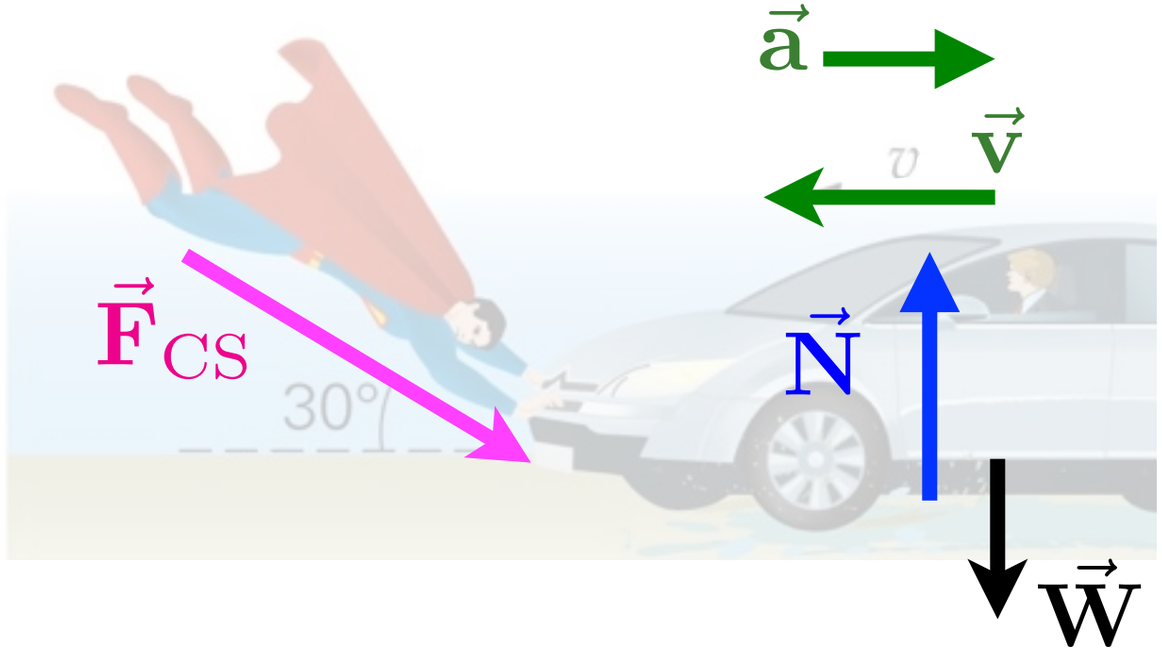

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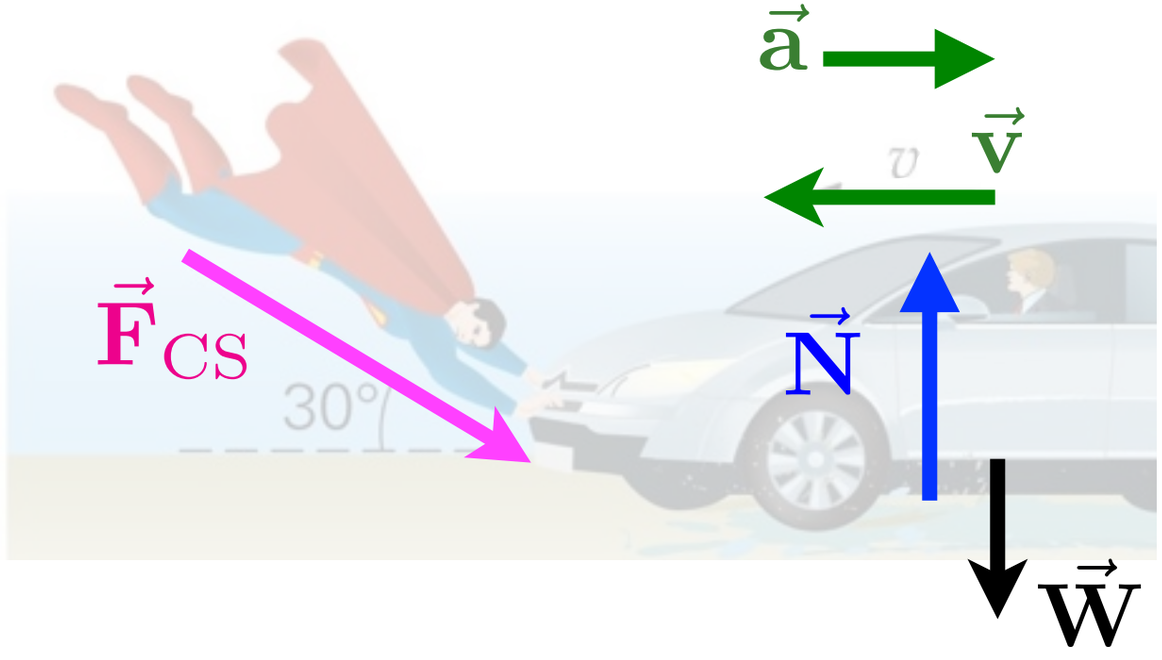

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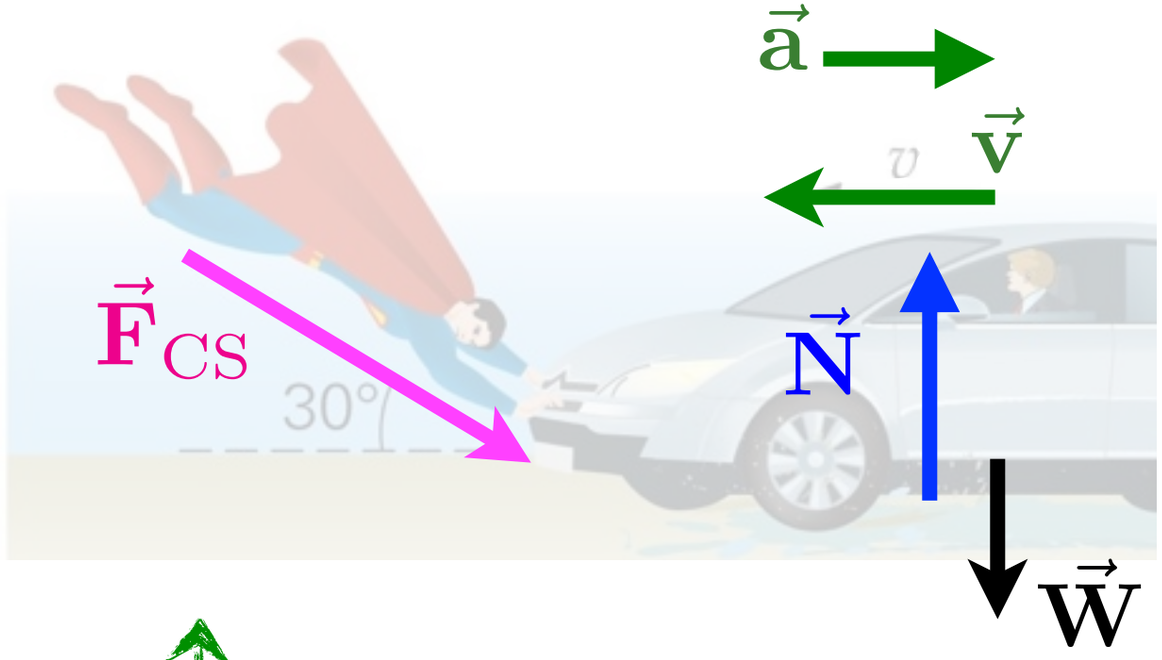

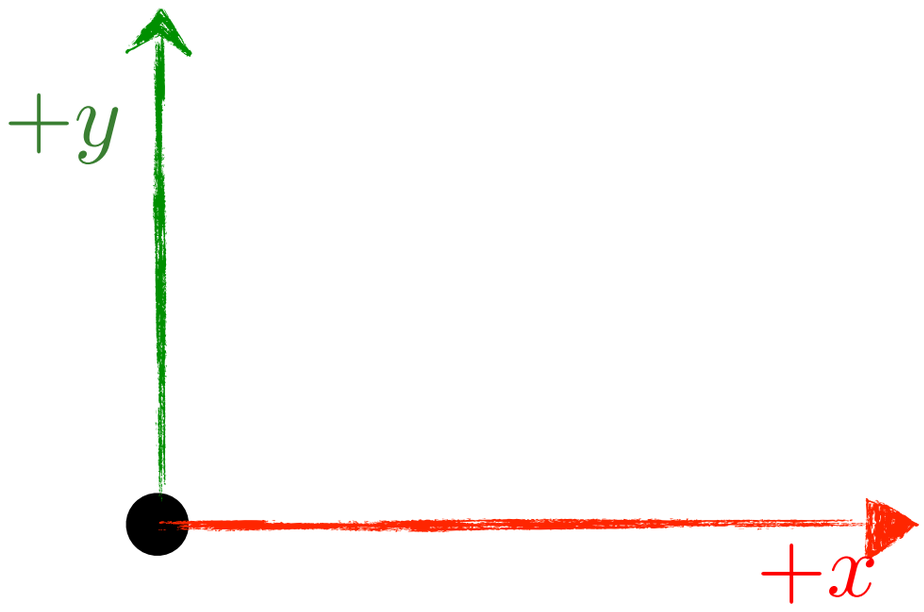

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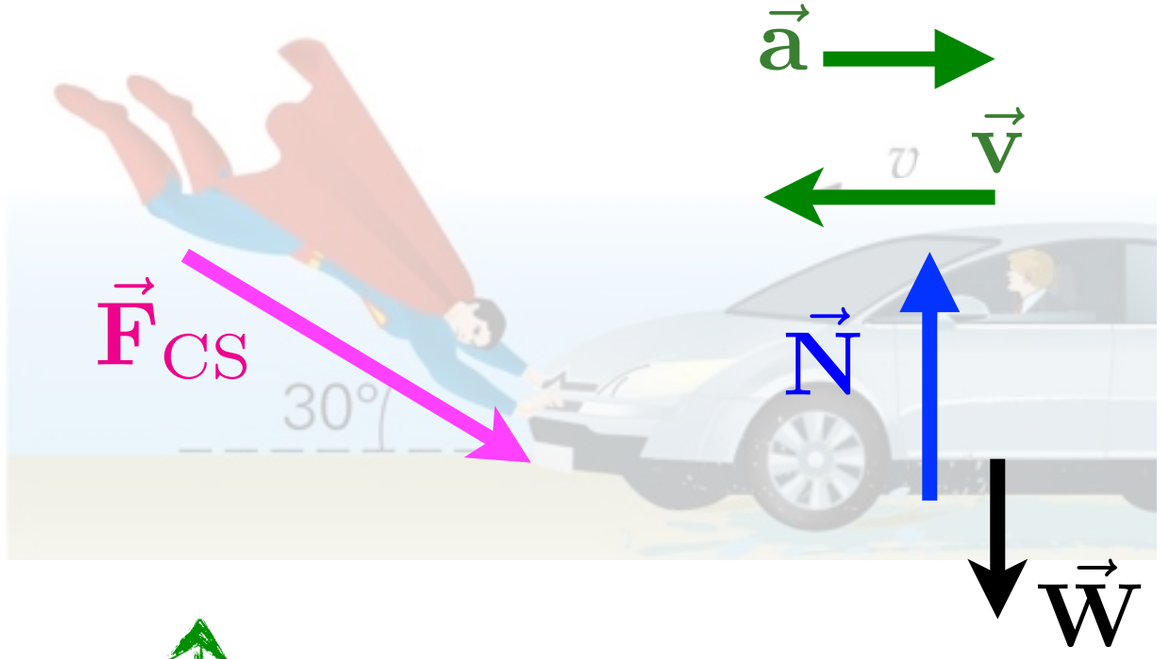

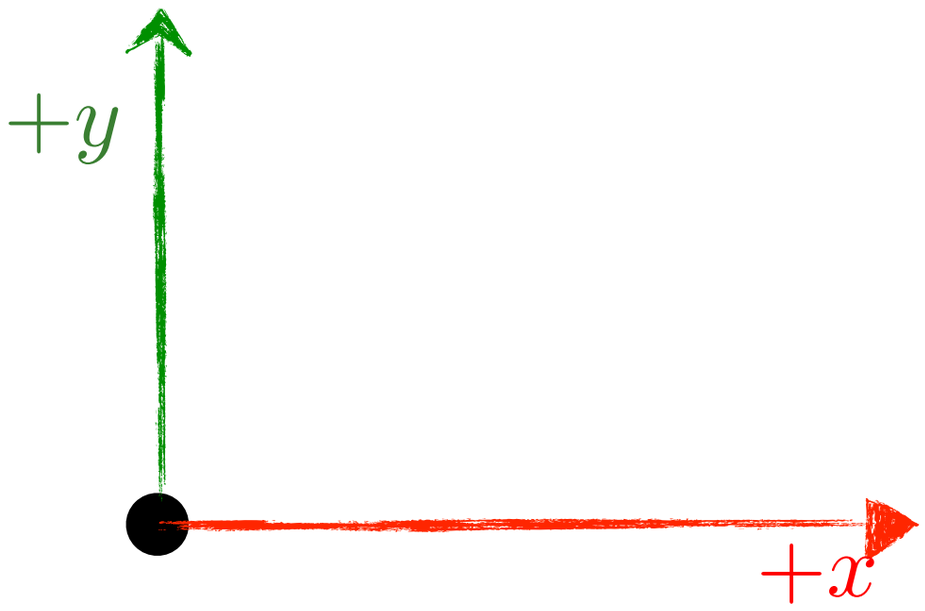

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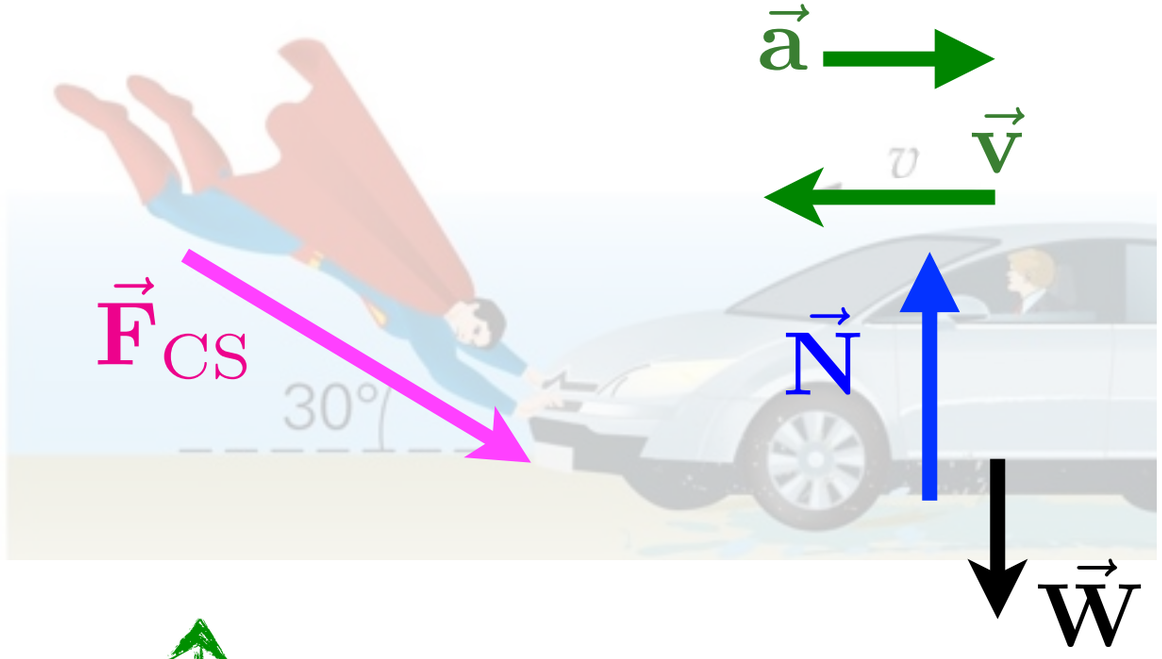

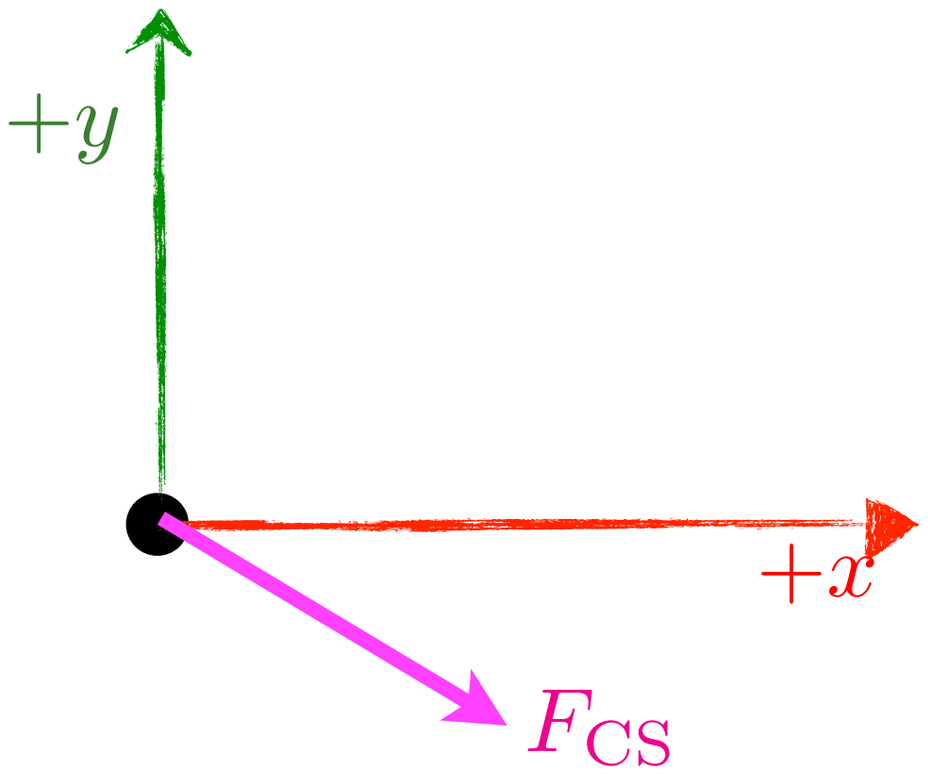

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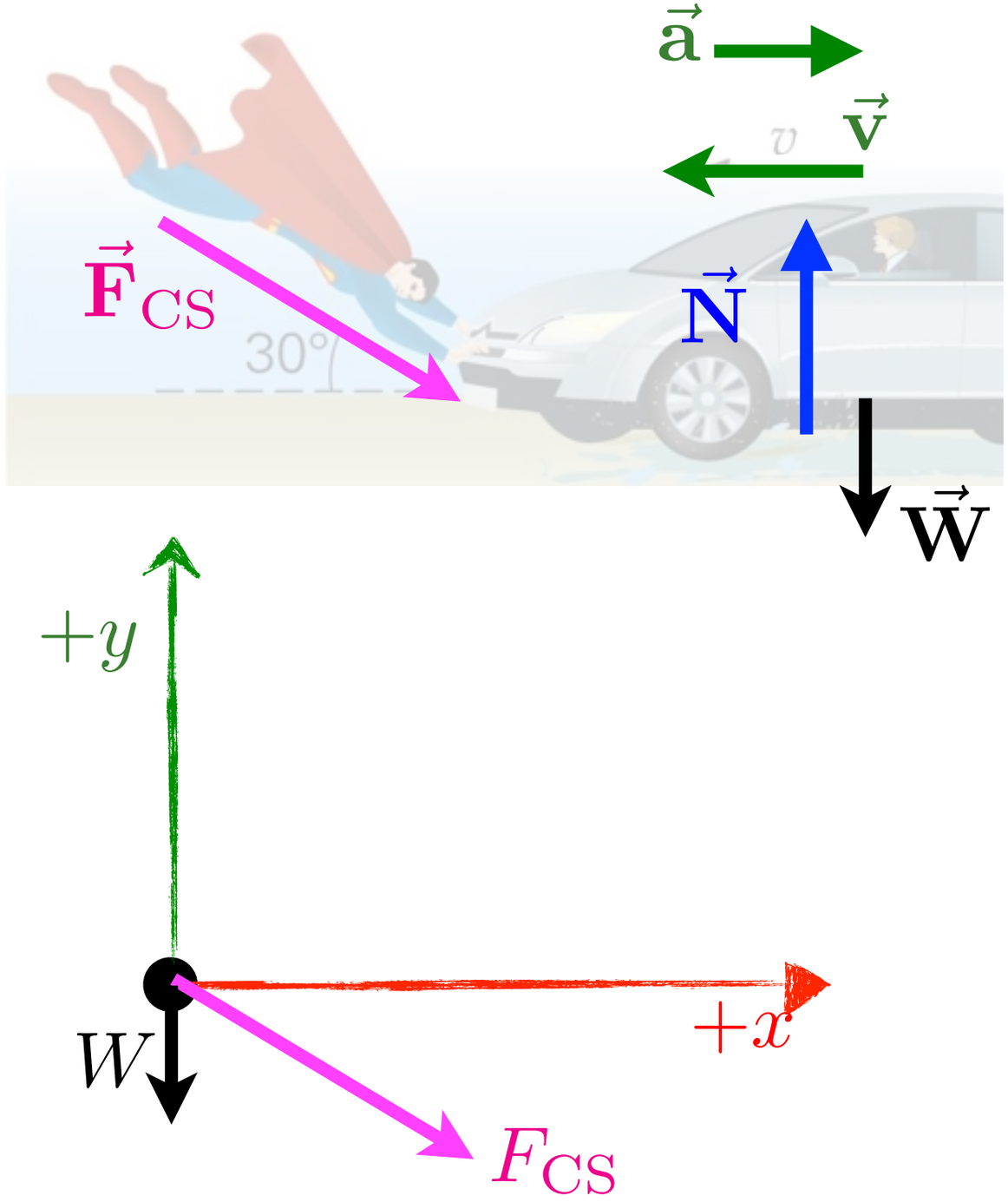

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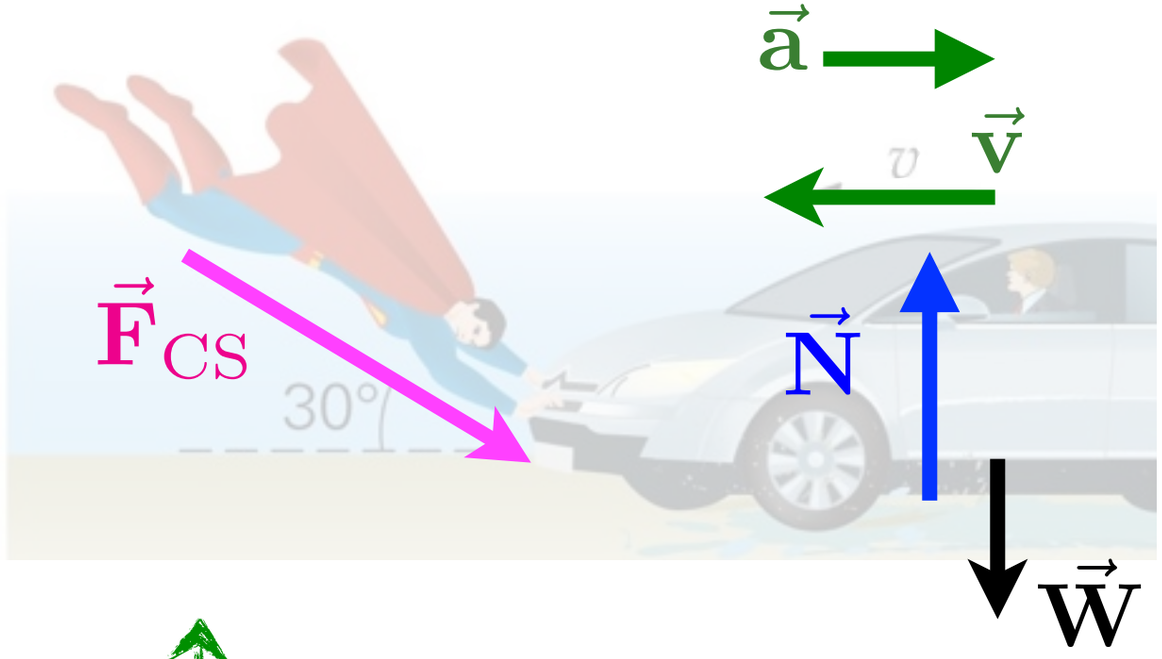

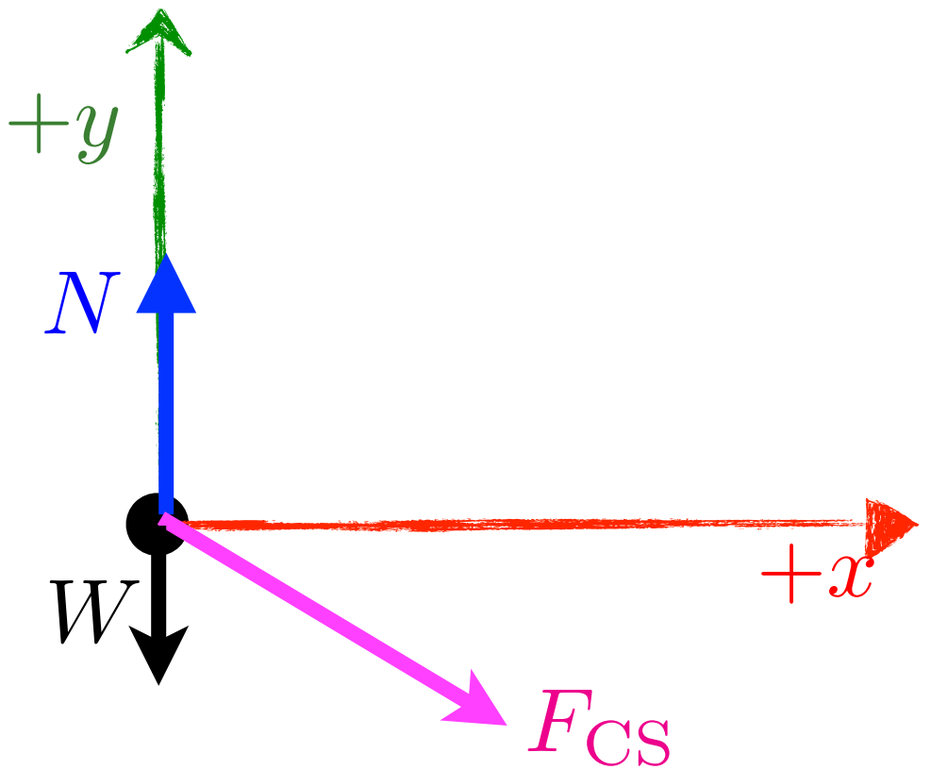

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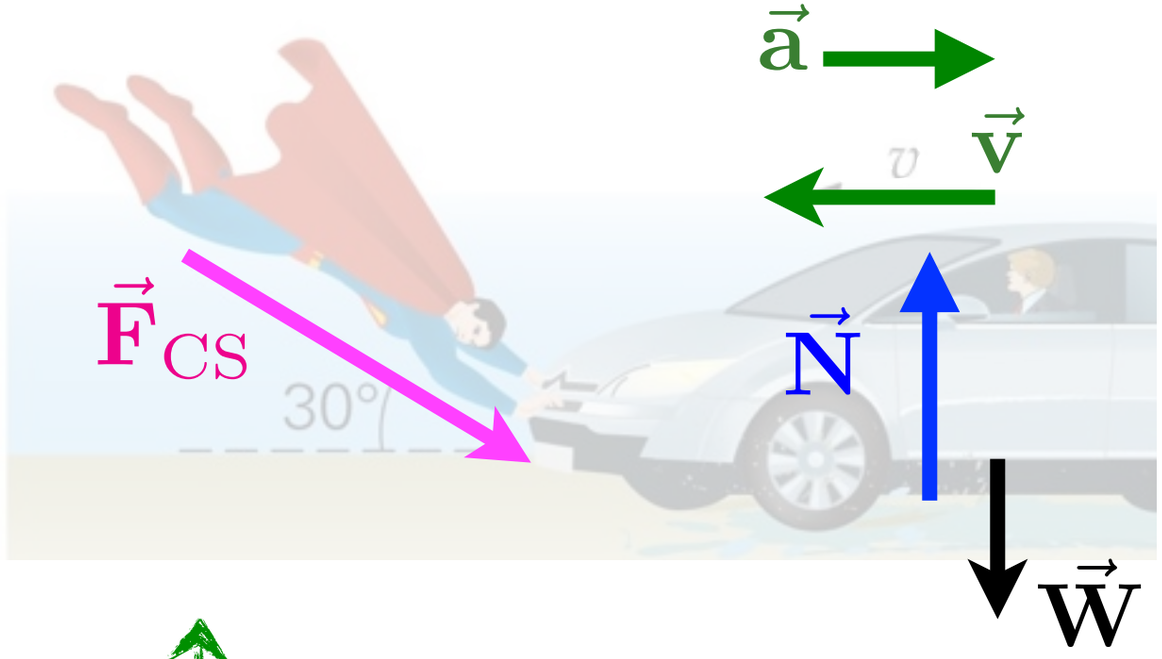
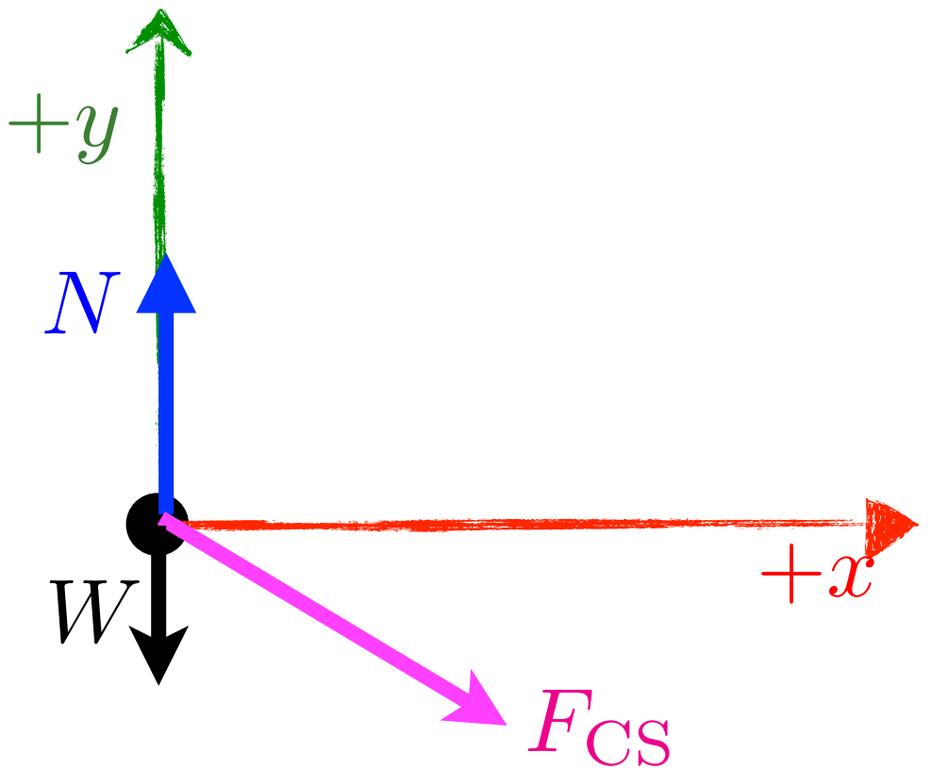
- 3. Resolve components
  - Use colors or draw





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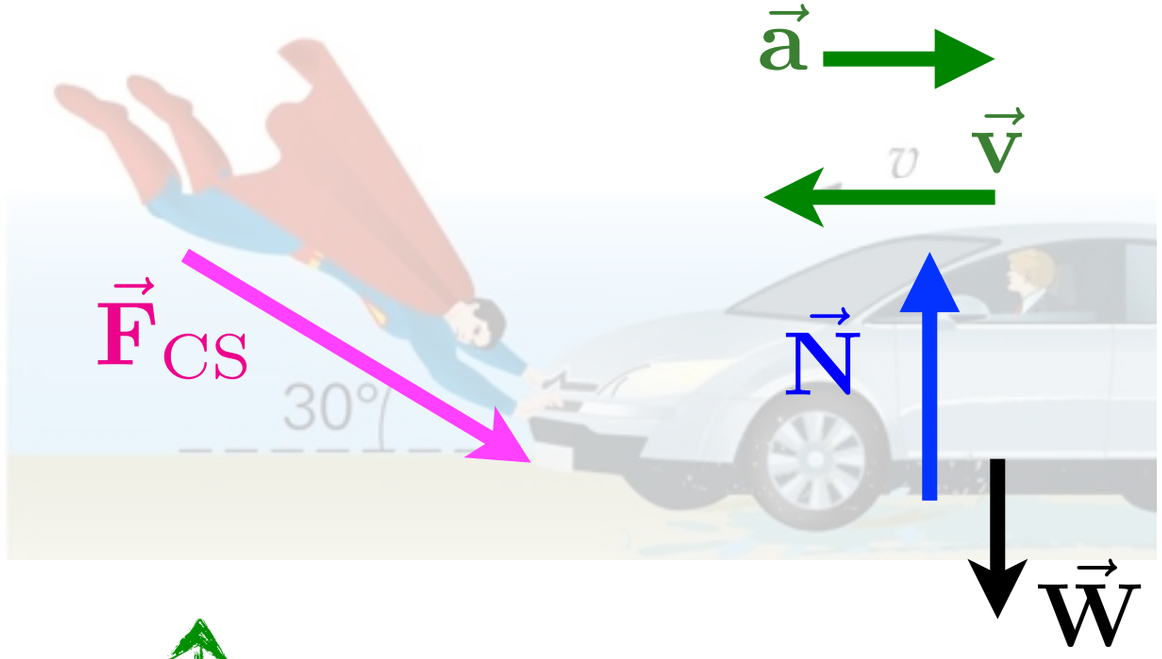

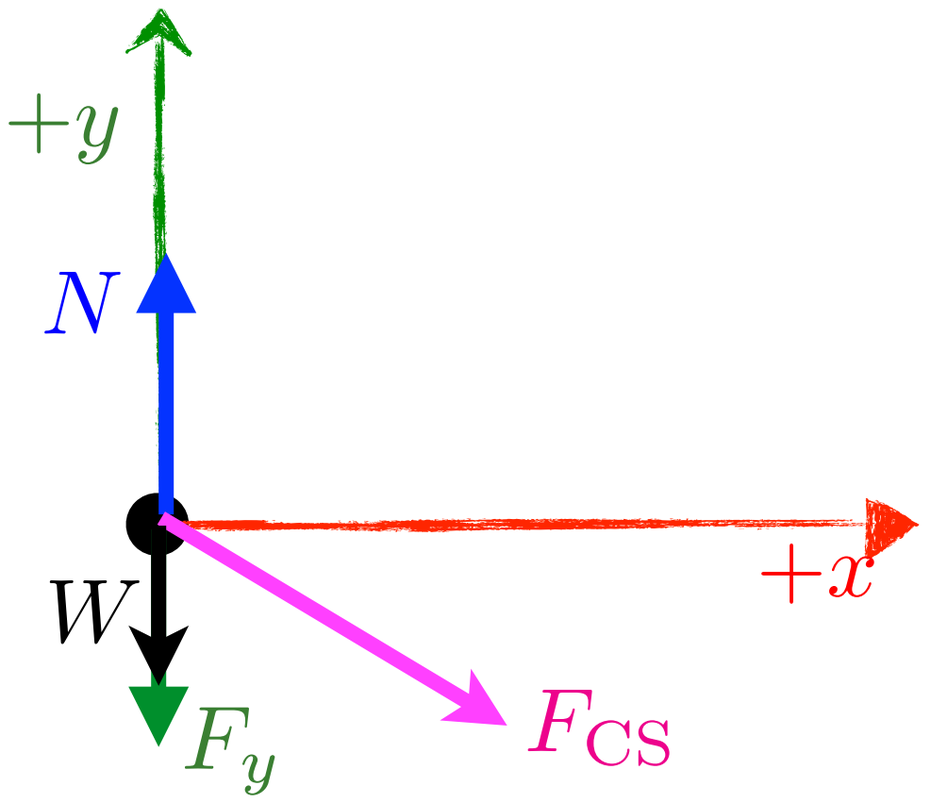

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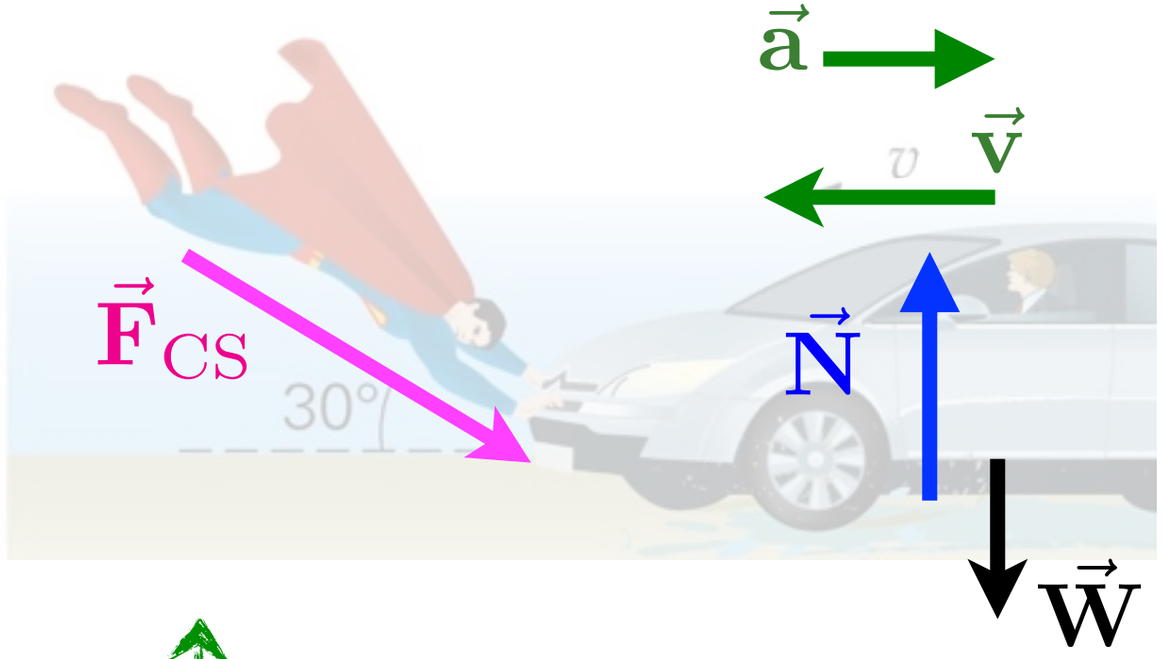

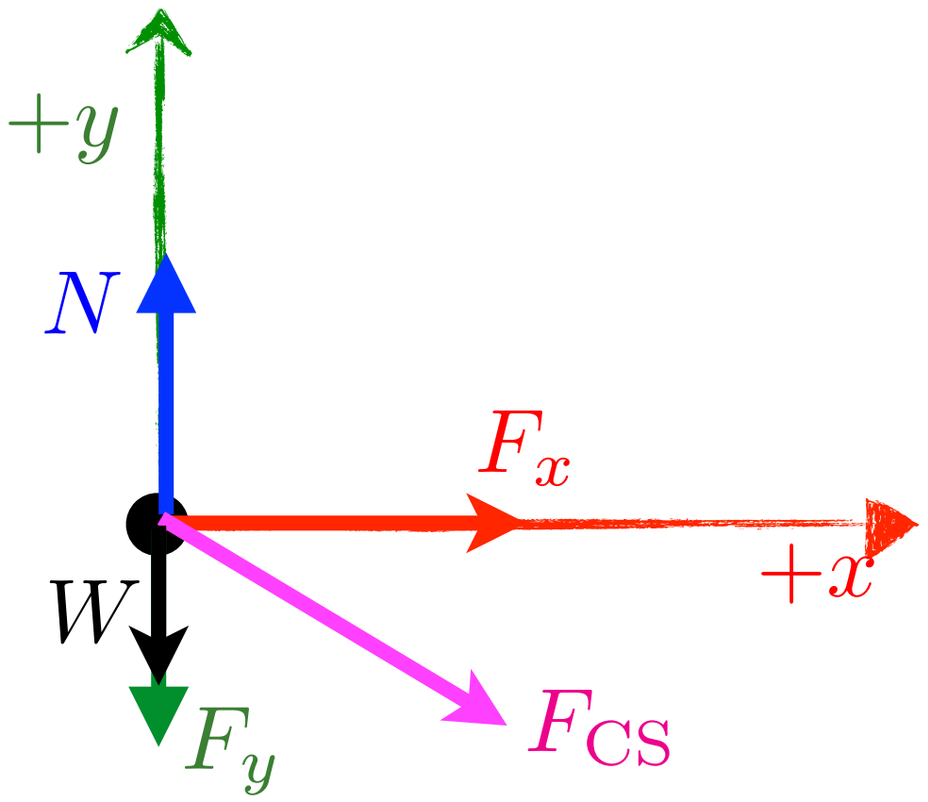

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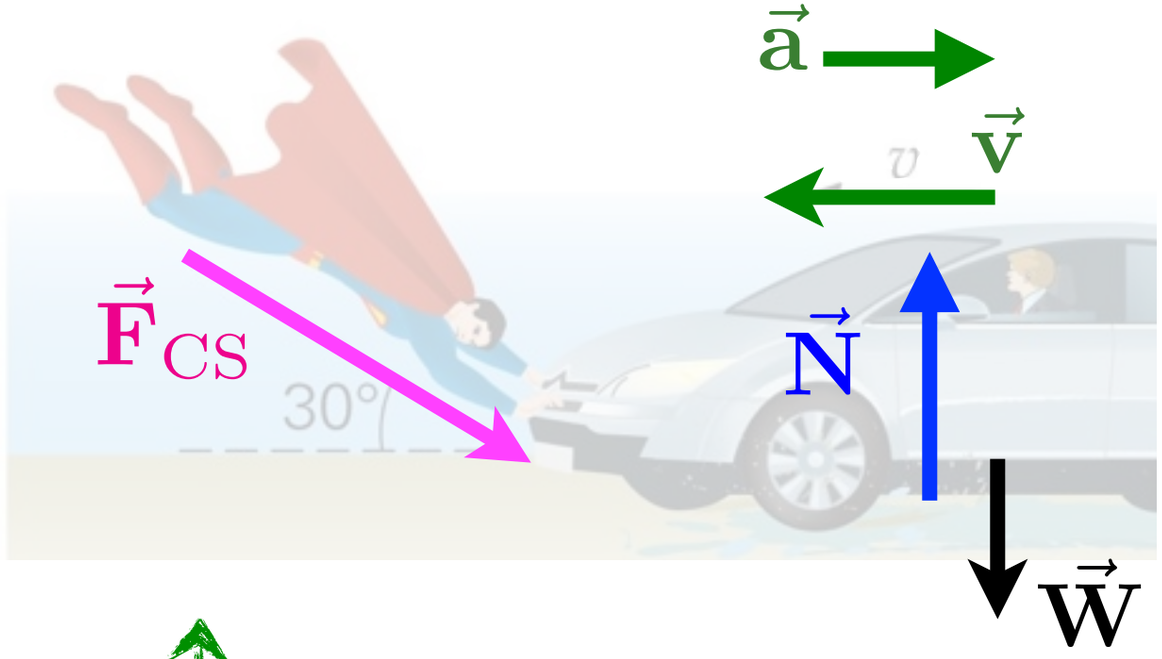

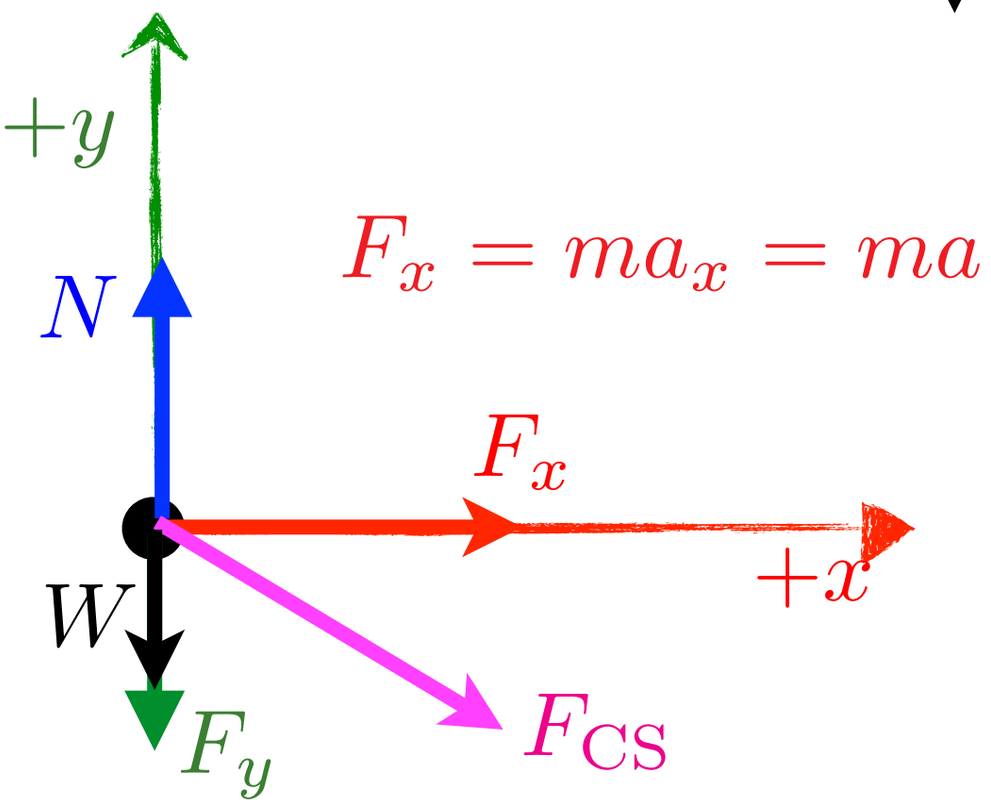

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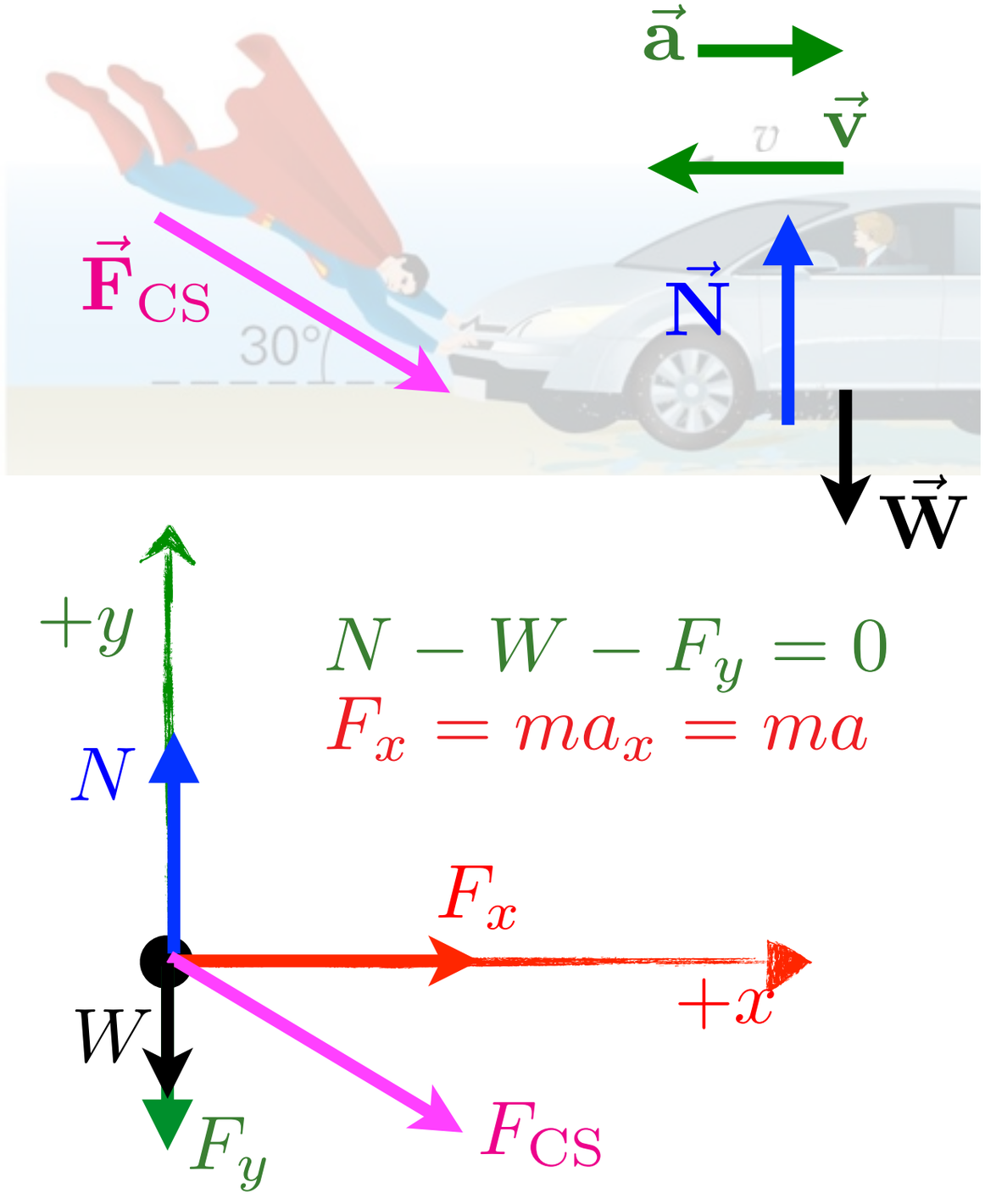


Lecture 12 outline

- Announcements
- Homework followup
- Class participation tutorial: second law

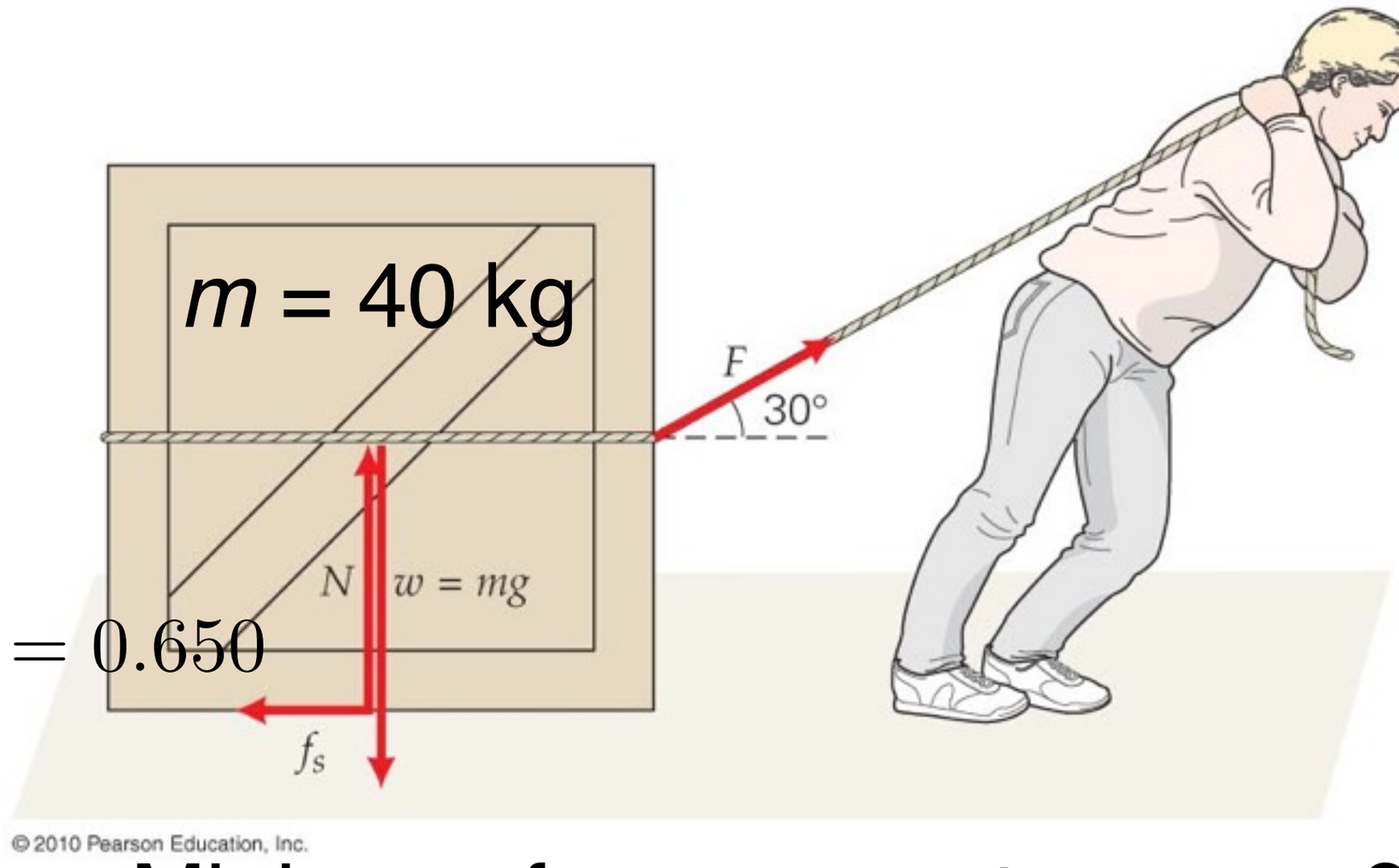
Tutorial

Formula sheet:

$$\vec{\mathbf{a}} = \vec{\mathbf{F}}_{\text{net}}/m$$

$$f_s^{\max} = \mu_s N$$

$$\mu_s = 0.650$$



Minimum force so crate moves?

Tutorial

- (After class, see also Ex. 4.11 in textbook)

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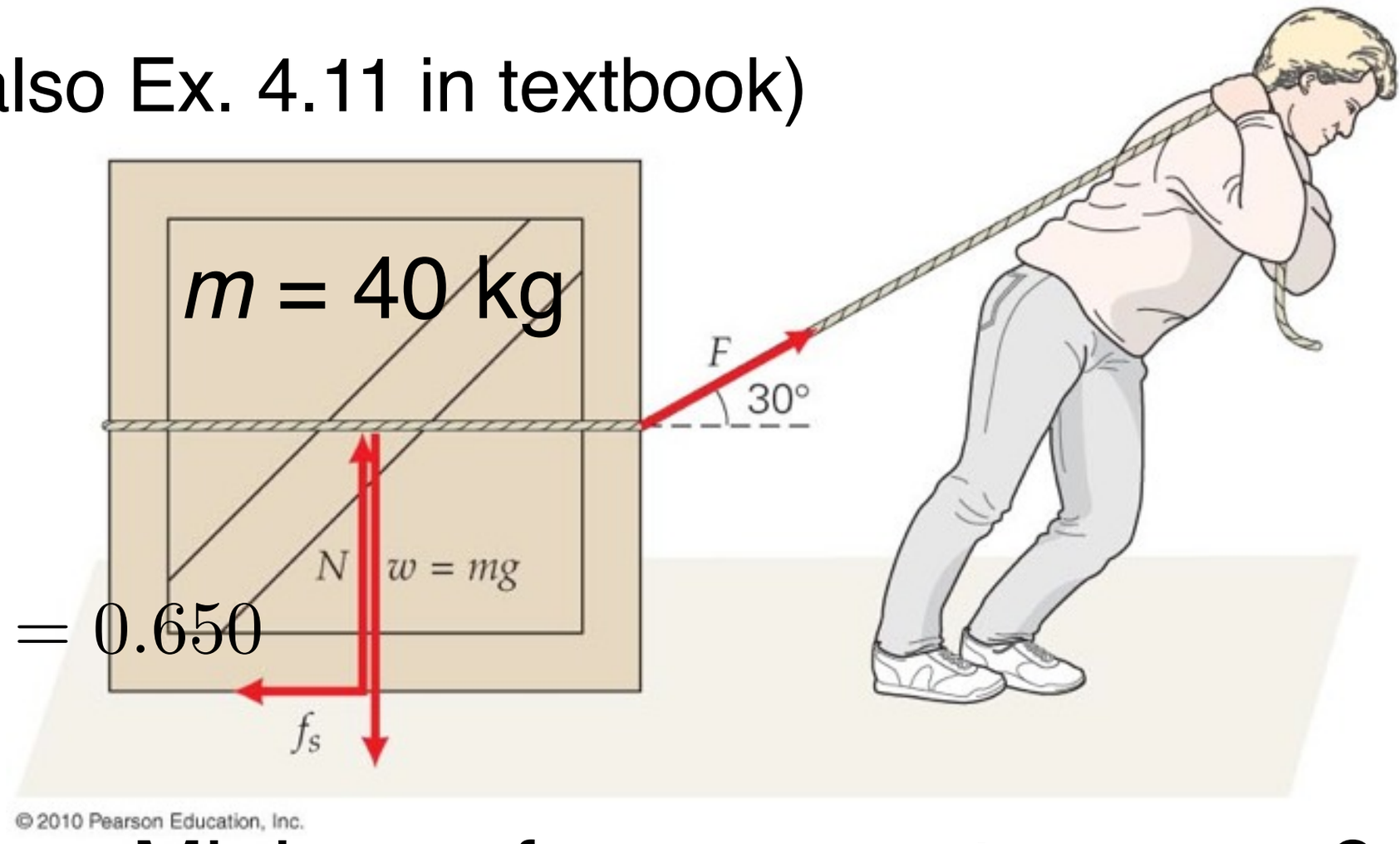

Minimum force so crate moves?

Lecture 12 outline

- Announcements
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- Work & energy
  - Constant force
  - Variable force example: spring

Homework #5 followup

- A. Multiple Choice Question 4.12
  - Kinematic equations = constant acceleration
  - Newton's second law $\vec{\mathbf{a}} = \vec{\mathbf{F}}_{\mathrm{net}}/m$
- So…

Clicker question #45

- The kinematic equation $x = x_0 + v_0 t + \frac{1}{2} a t^2$ can be used…

A Only with constant forces

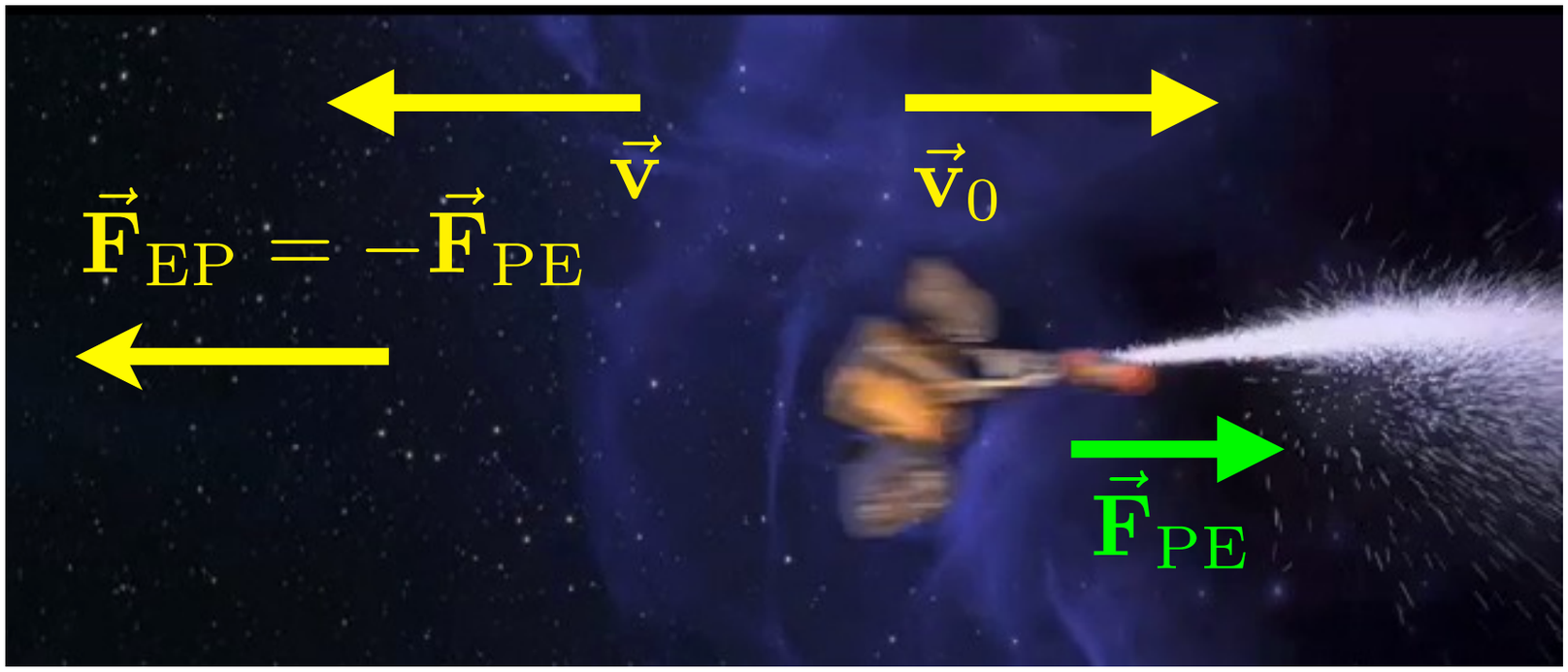
B With variable accelerations

C Only with constant velocities

D A, B, and C

Homework #5 followup

- If force $\vec{\mathbf{F}}_{\mathrm{AB}}$ *on* A *by* B, then…
  - Force *on* B *by* A is $\vec{\mathbf{F}}_{\mathrm{BA}} = -\vec{\mathbf{F}}_{\mathrm{AB}}$
  - Relates forces acting on *different* objects
- So…



Clicker question #46

- Given force on Earth by Moon $\vec{\mathbf{F}}_{\mathrm{EM}}$, Newton's third law says the force on Moon by Earth $\vec{\mathbf{F}}_{\mathrm{ME}}$ is _____ $\vec{\mathbf{F}}_{\mathrm{EM}}$?

A Greater in magnitude than, opposite in direction from

B Greater in magnitude than, in the same direction as

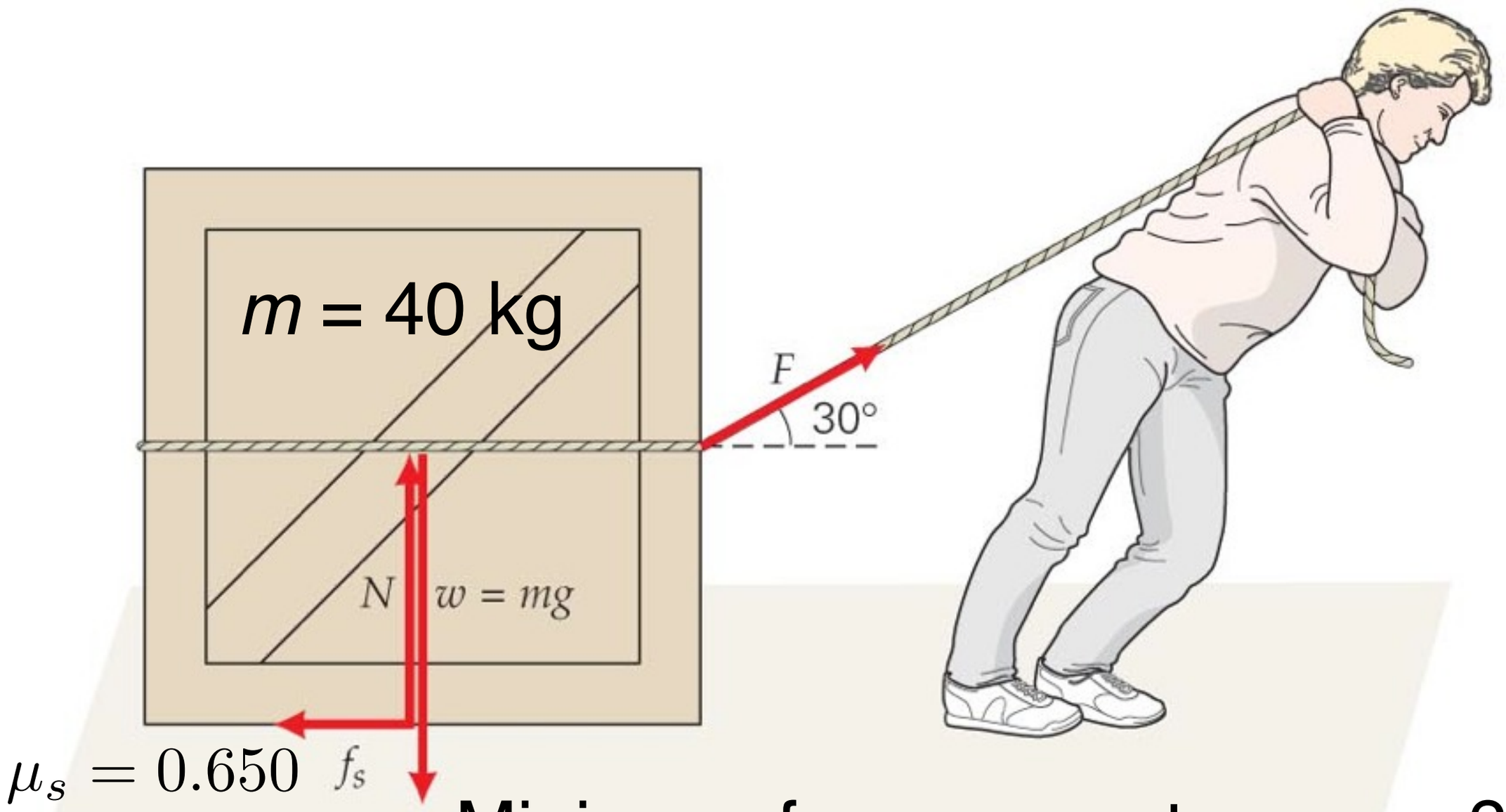
C Equal in magnitude to, opposite in direction from

D Smaller in magnitude than, opposite in direction from

Smaller in magnitude than, in the same direction as

Ex. 4.11

Given: $\theta = 30^\circ$, μ_s, m, g
Goal: Min. F so crate moves



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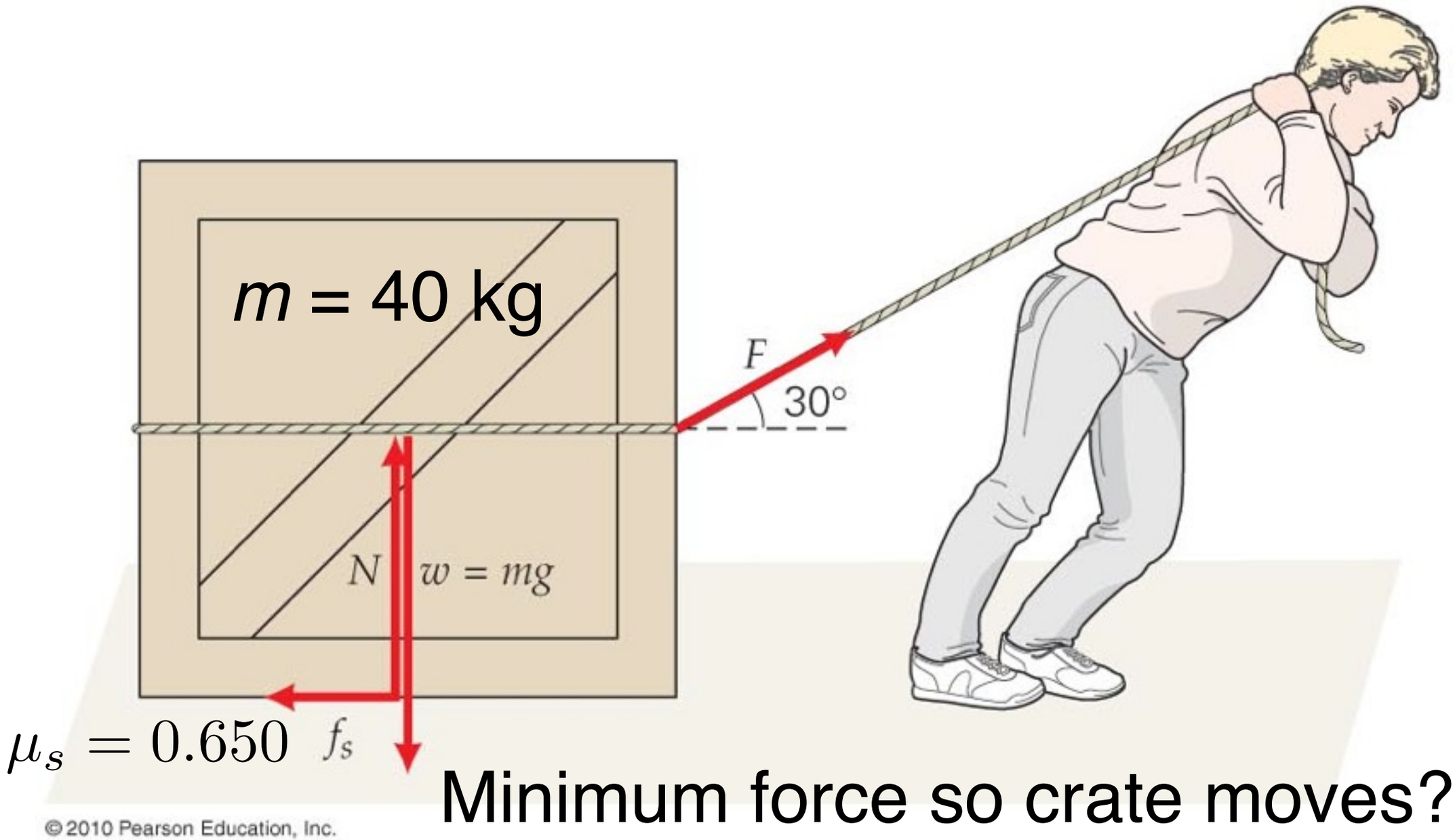

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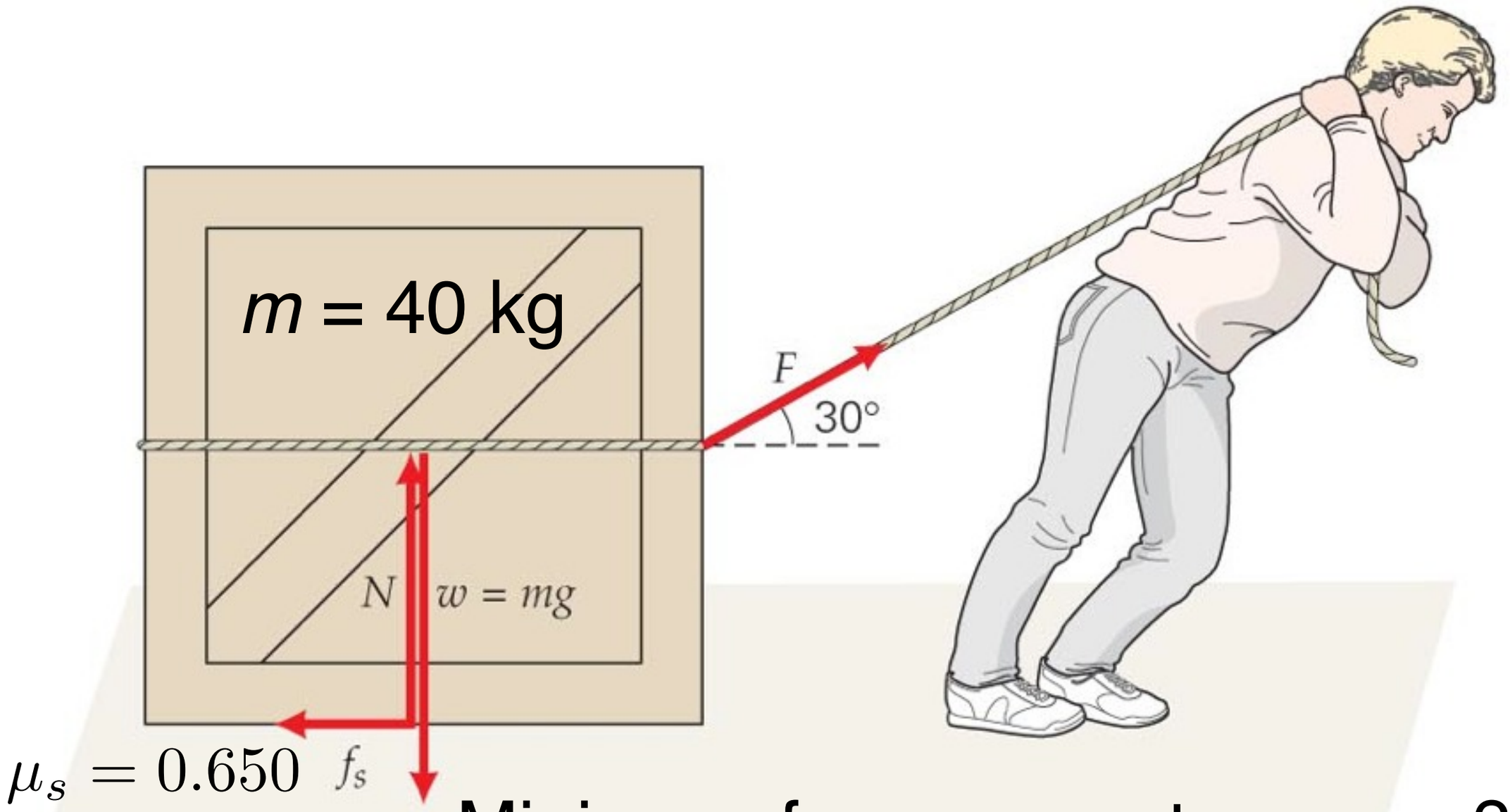

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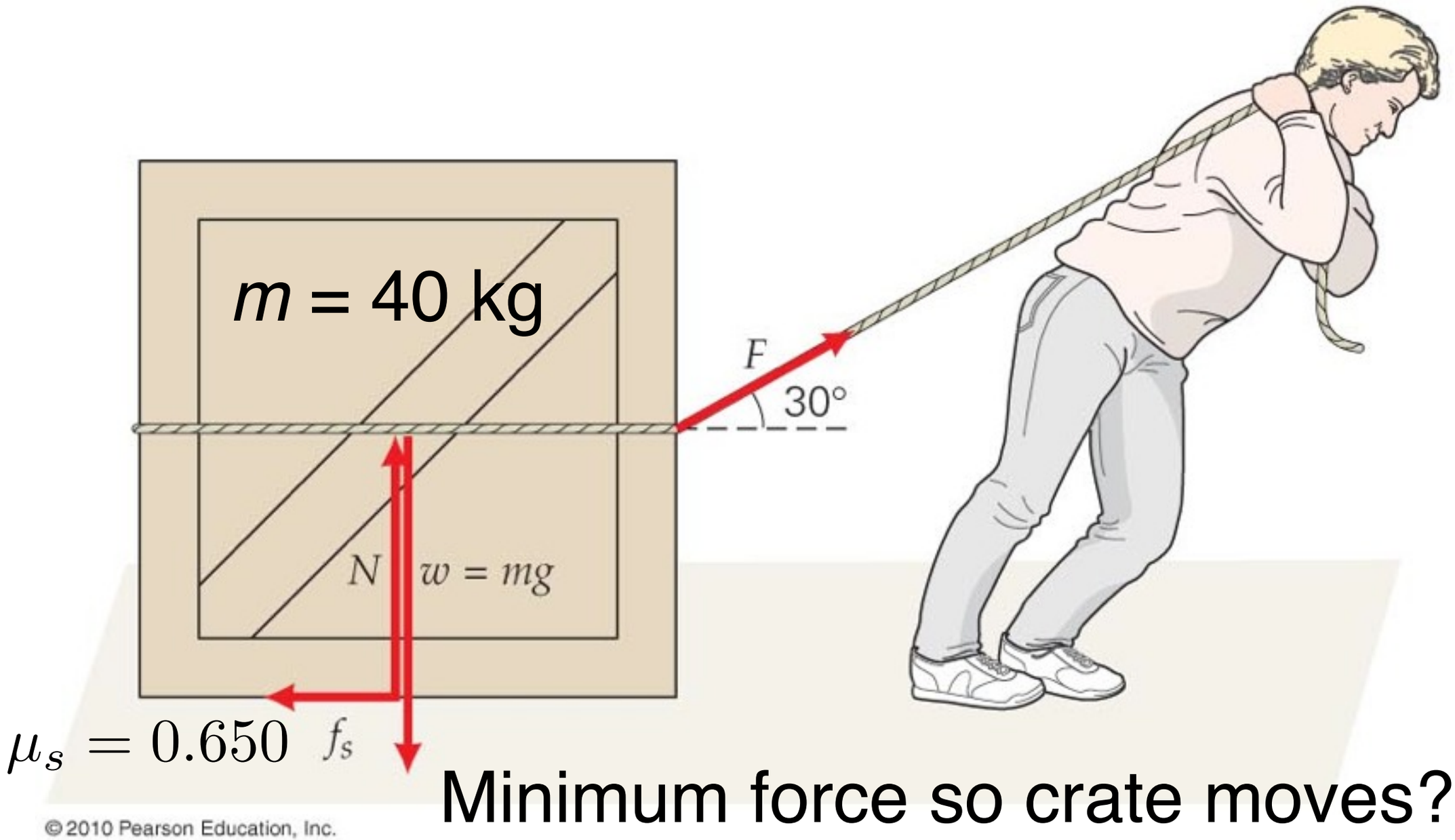

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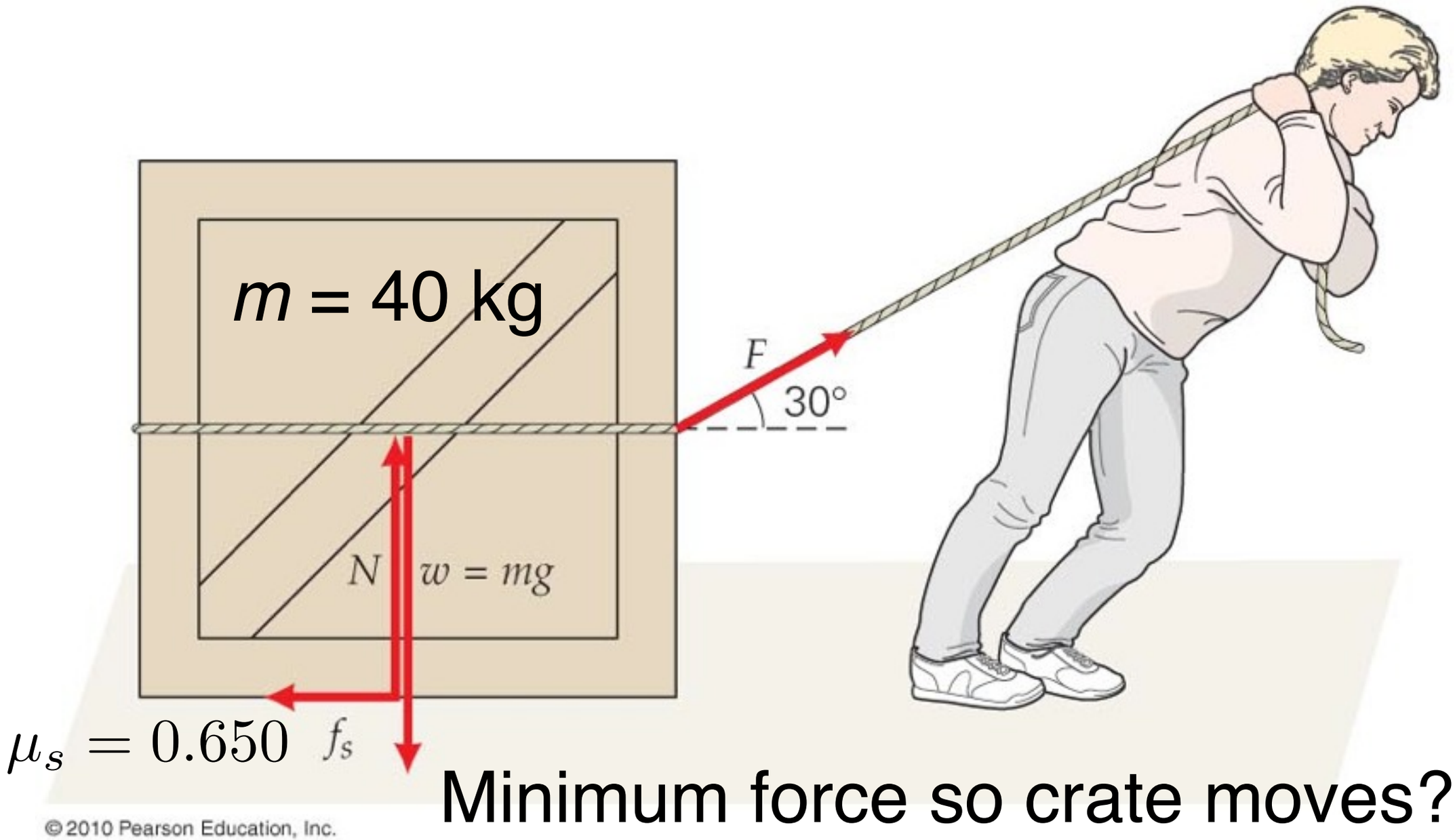

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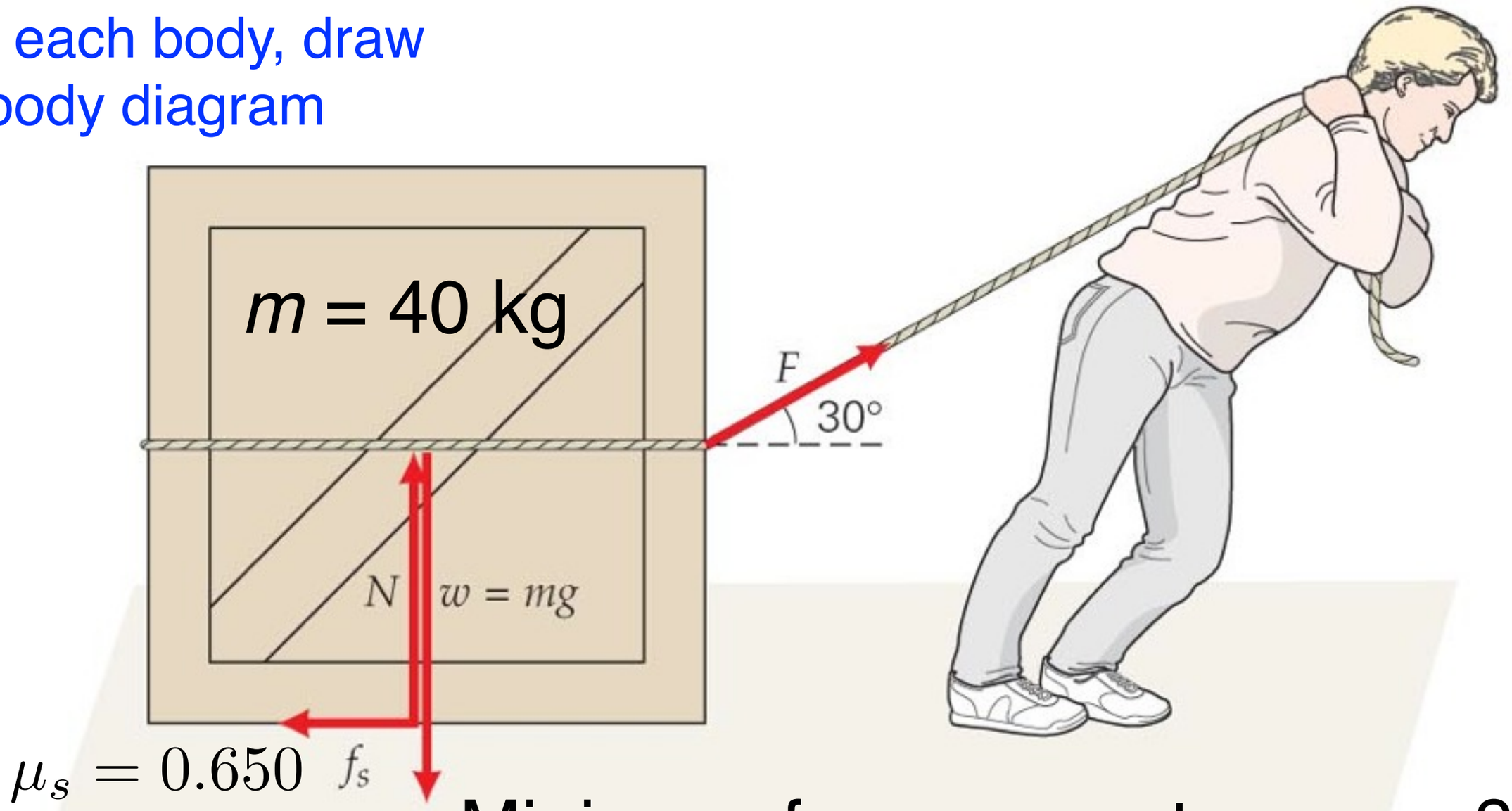
   4a. For each body, draw a free-body diagram



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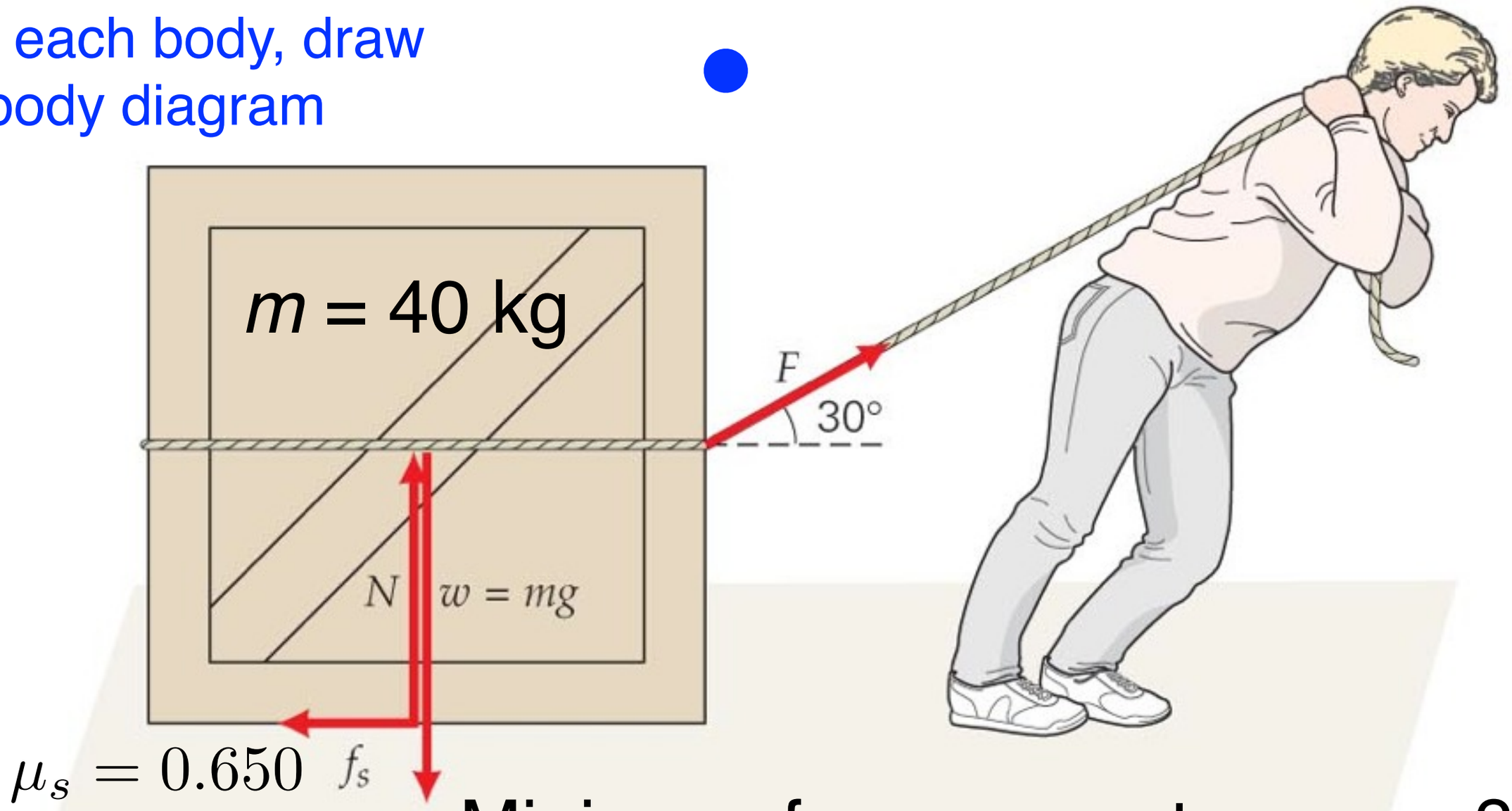

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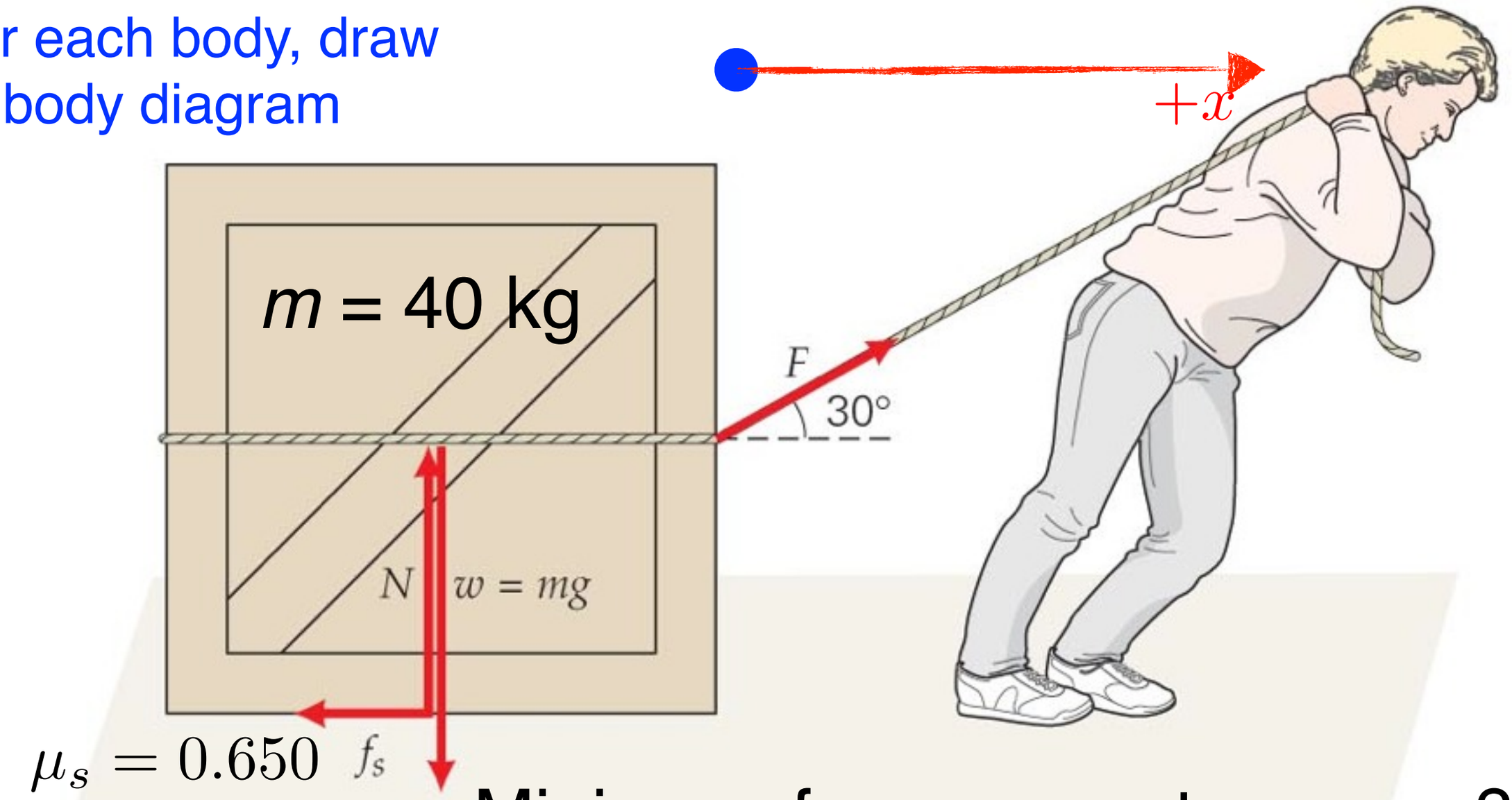

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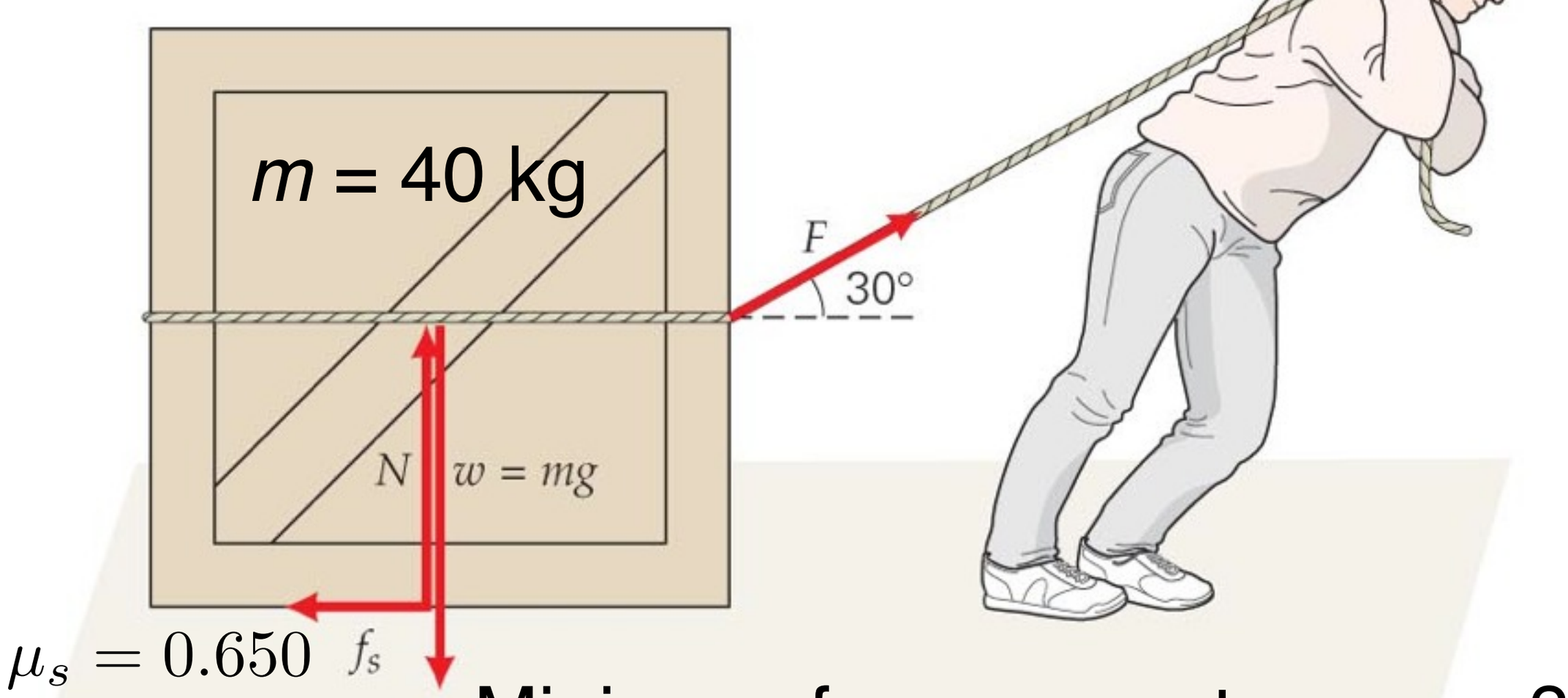

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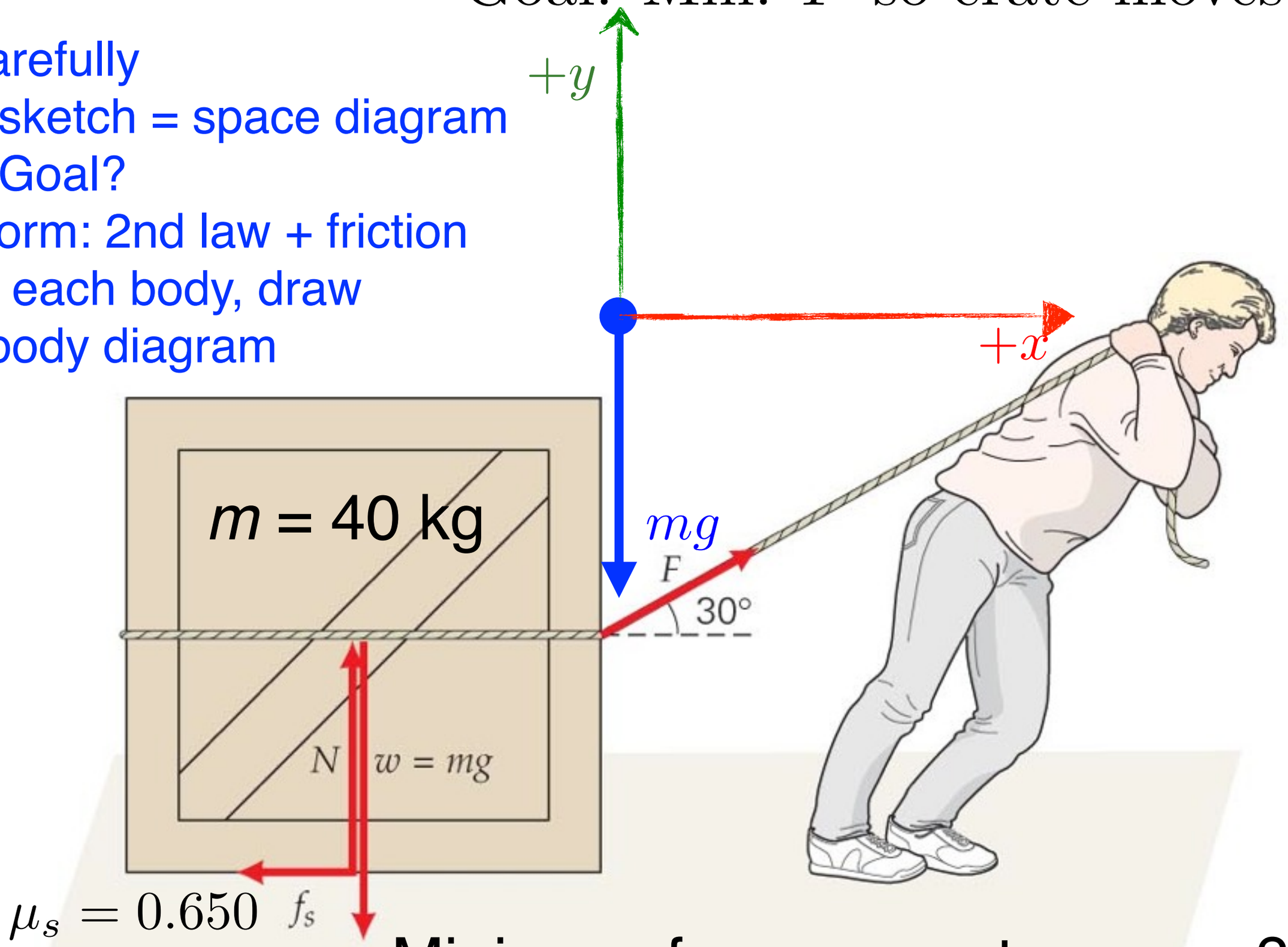

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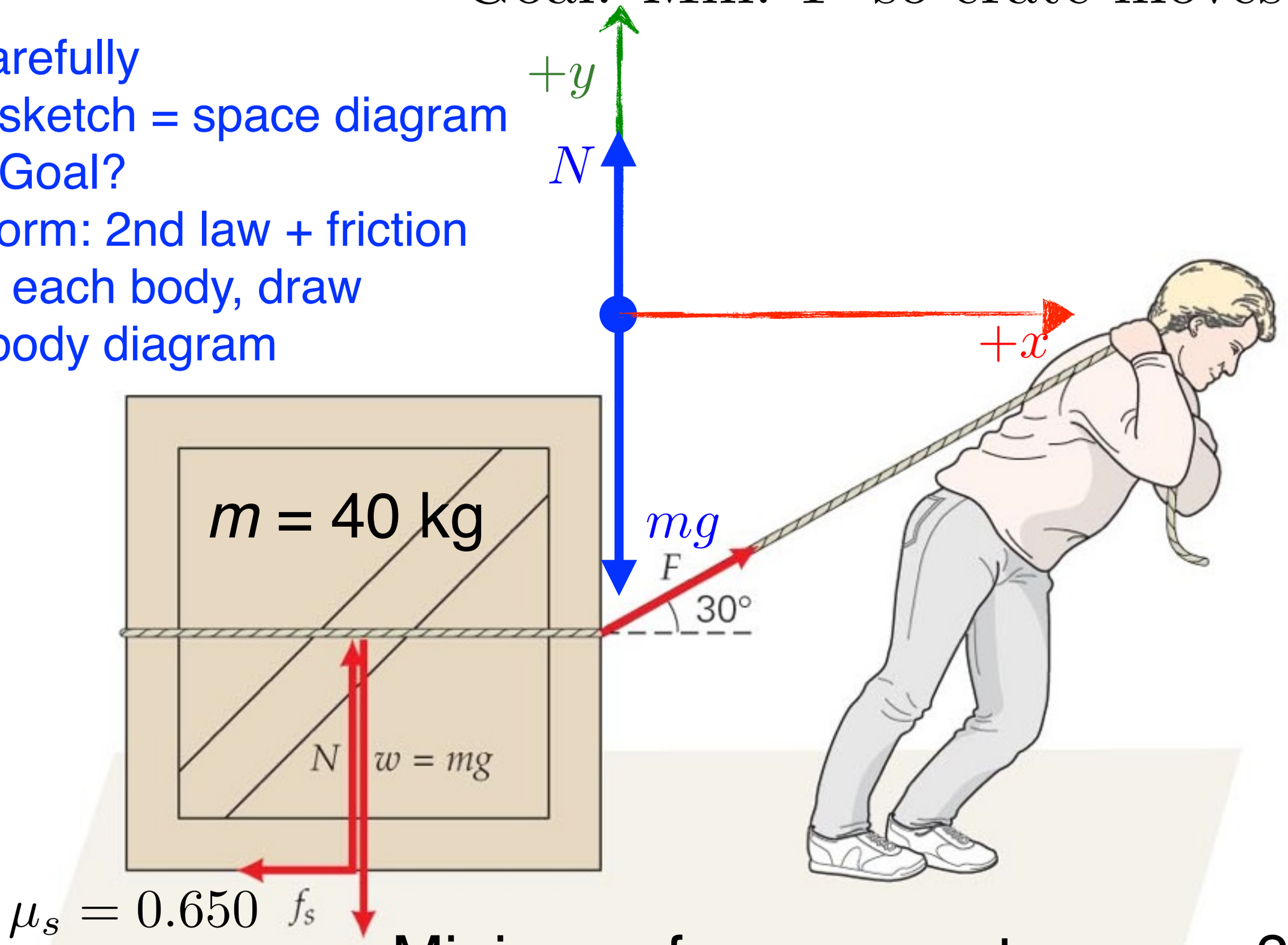

Minimum force so crate moves?

Ex. 4.11

Given: $\theta = 30°$, μ_s, m, g

Goal: Min. F so crate moves

1. Read carefully
2. Draw a sketch = space diagram
3. Given? Goal?
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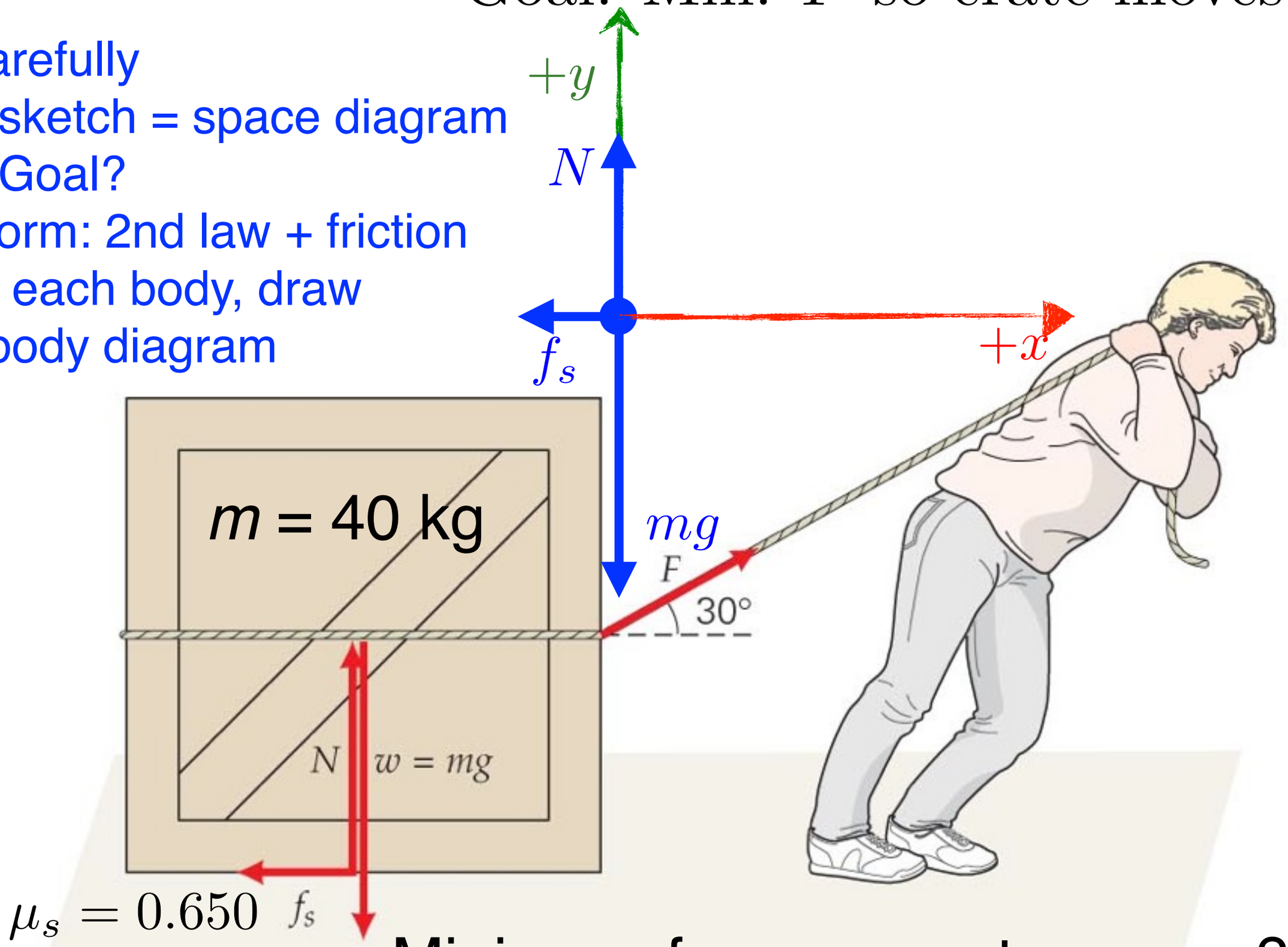

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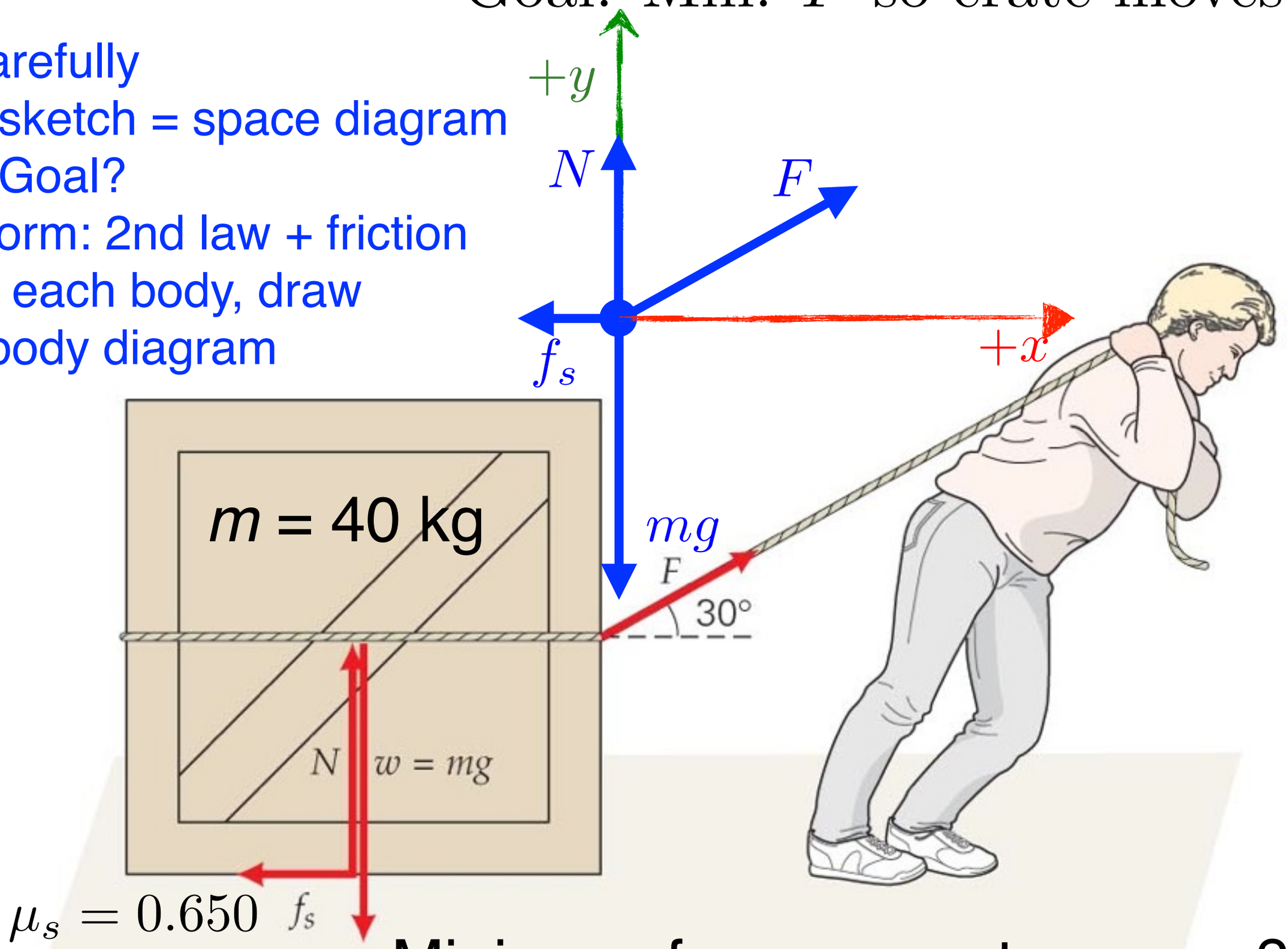

$\mu_s = 0.650$

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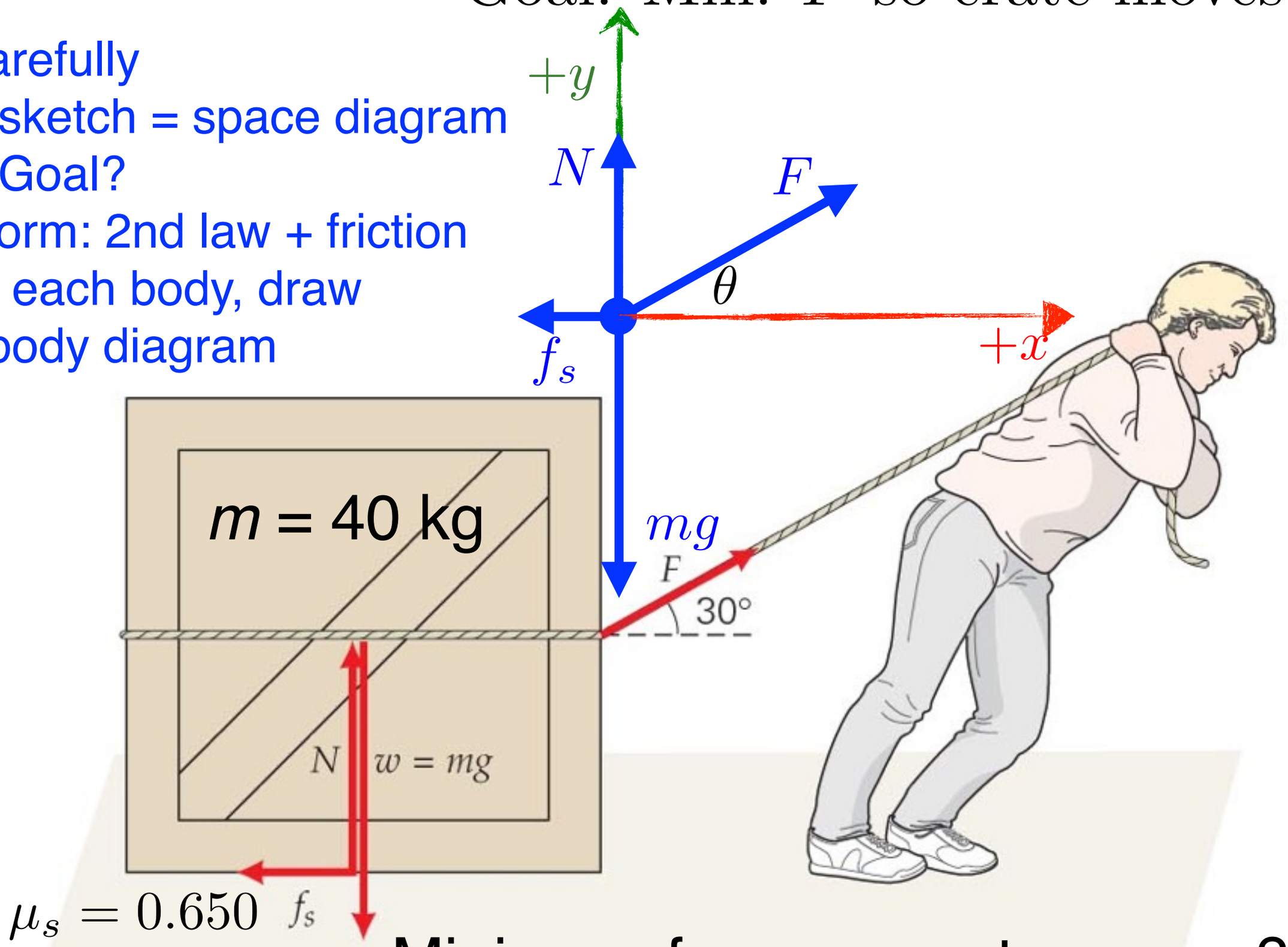

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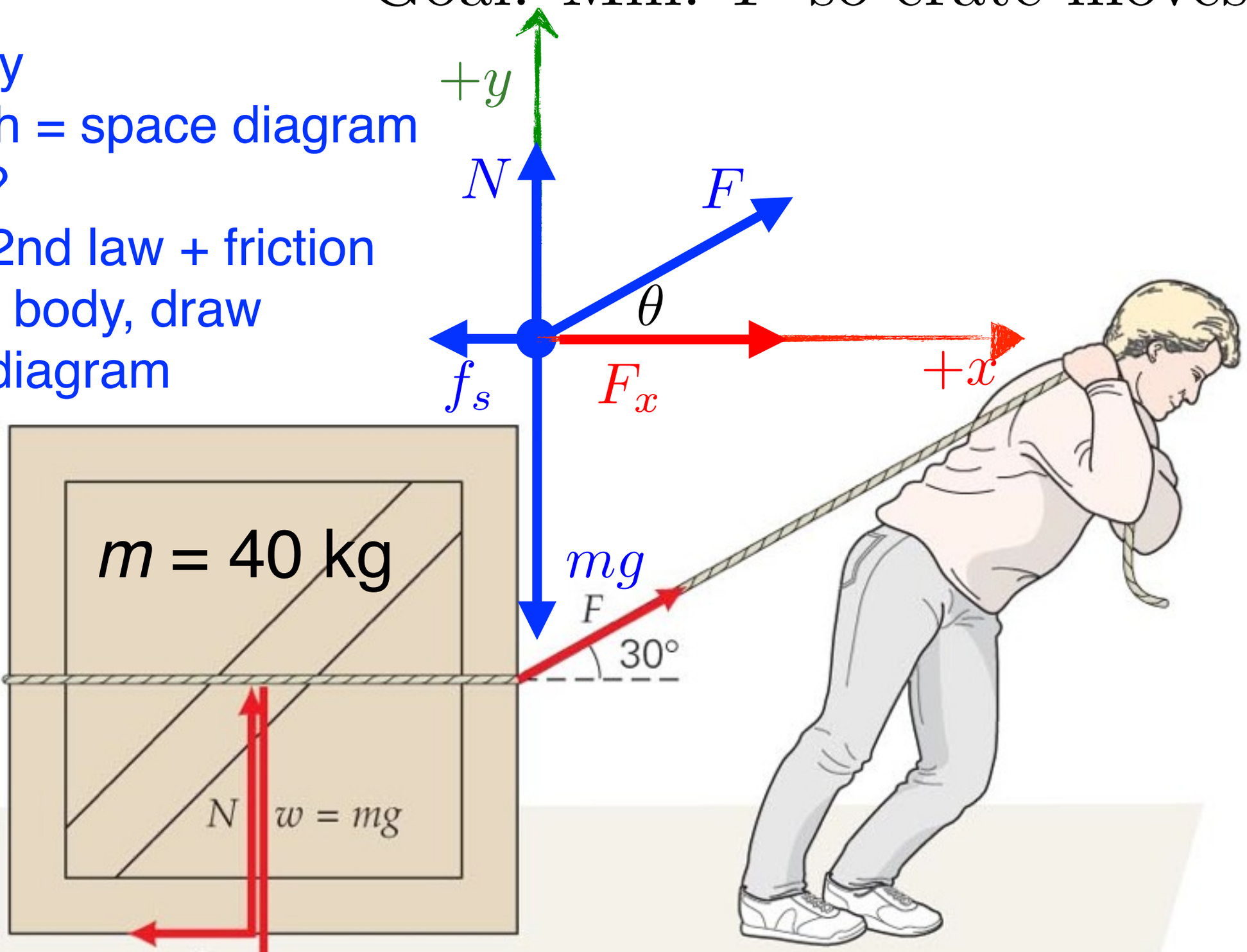

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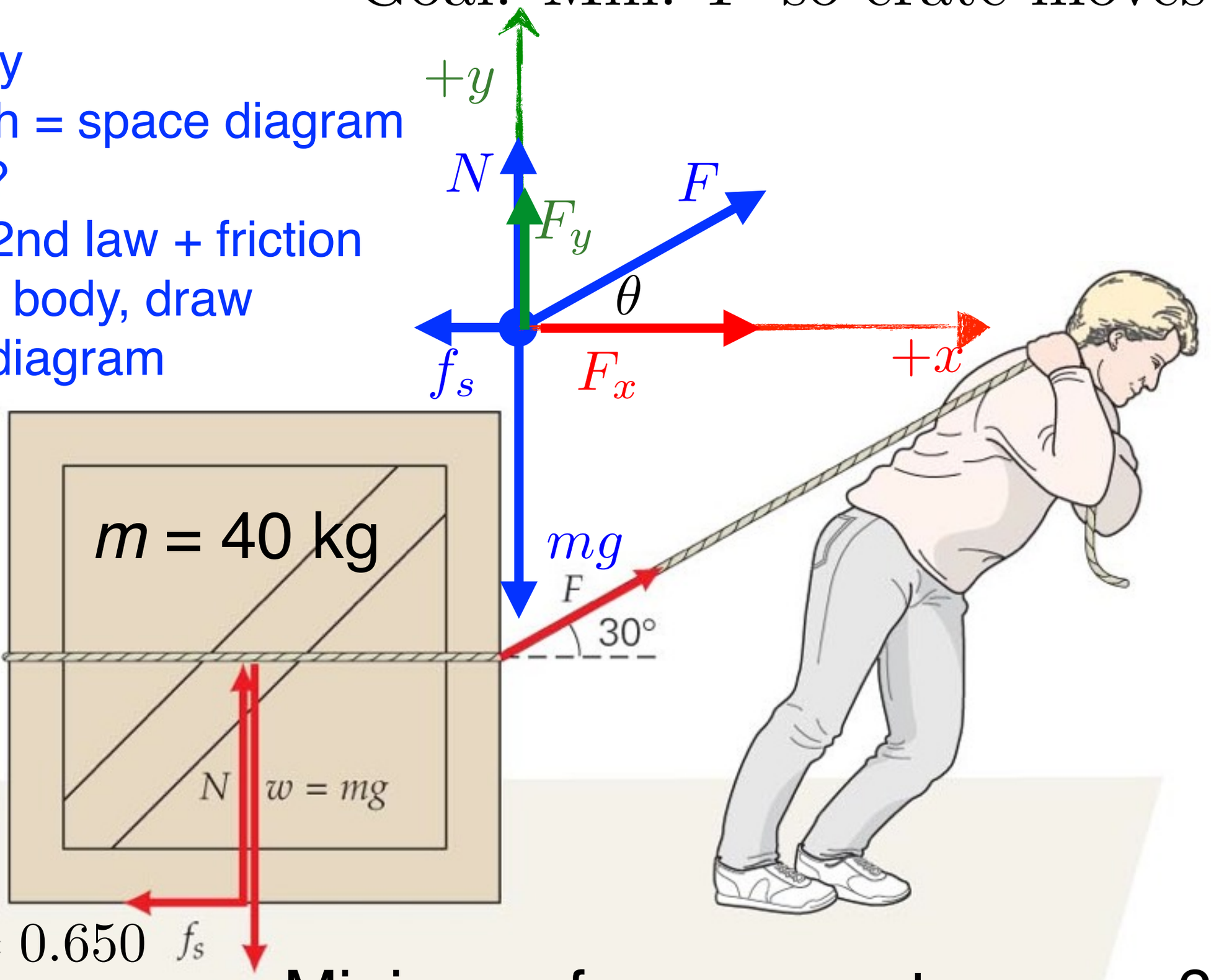
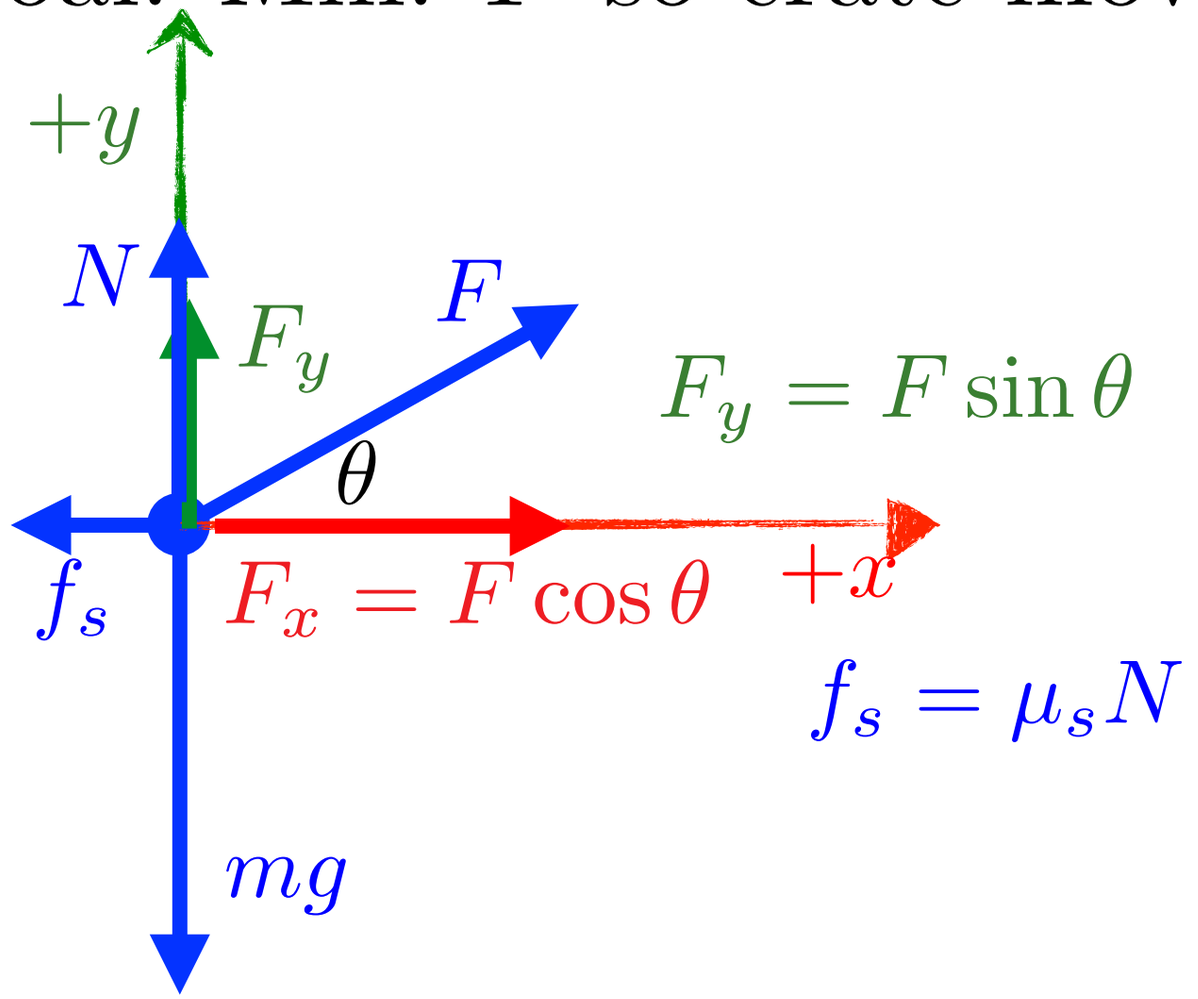


Minimum force so crate moves?

Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

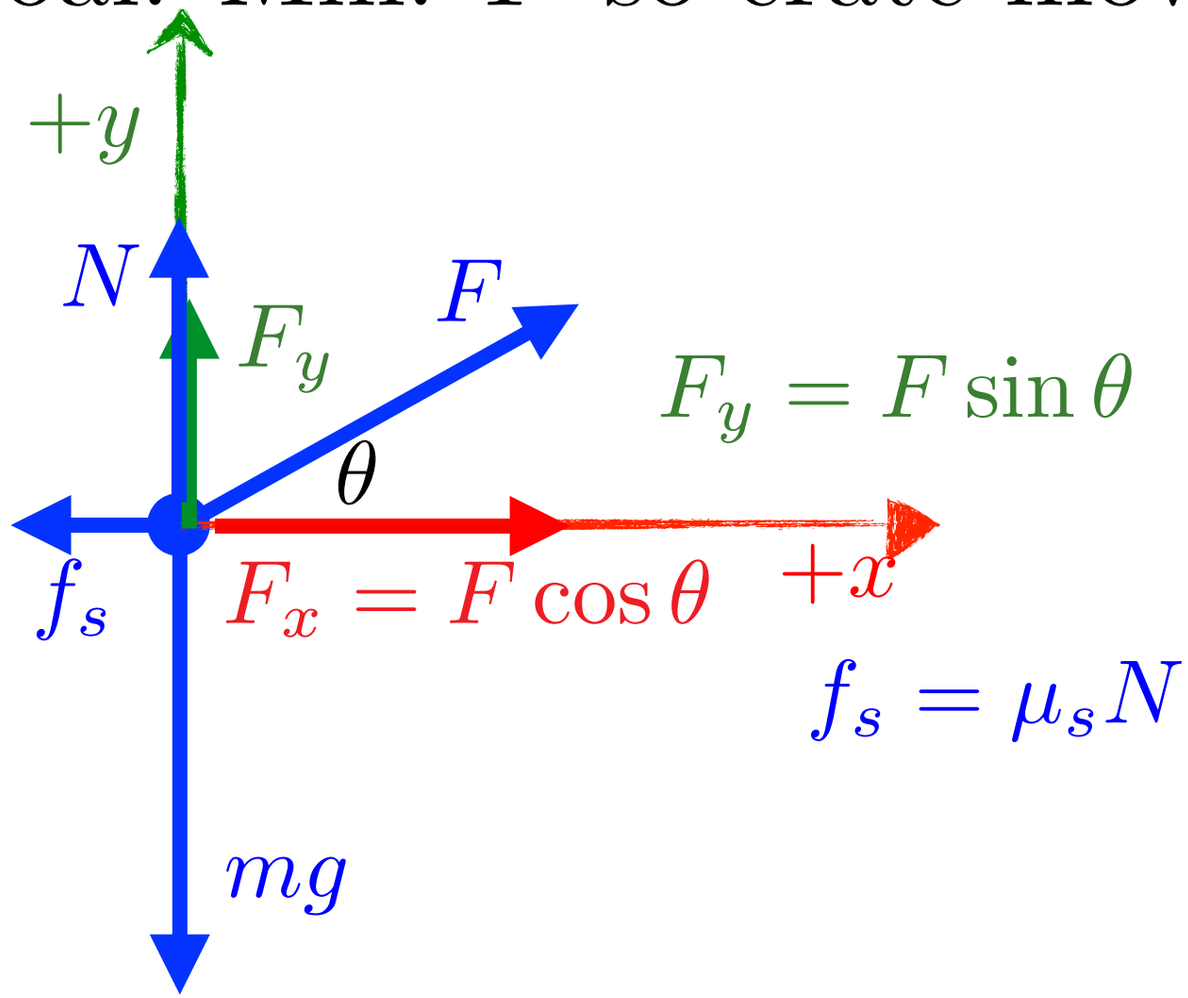


Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate



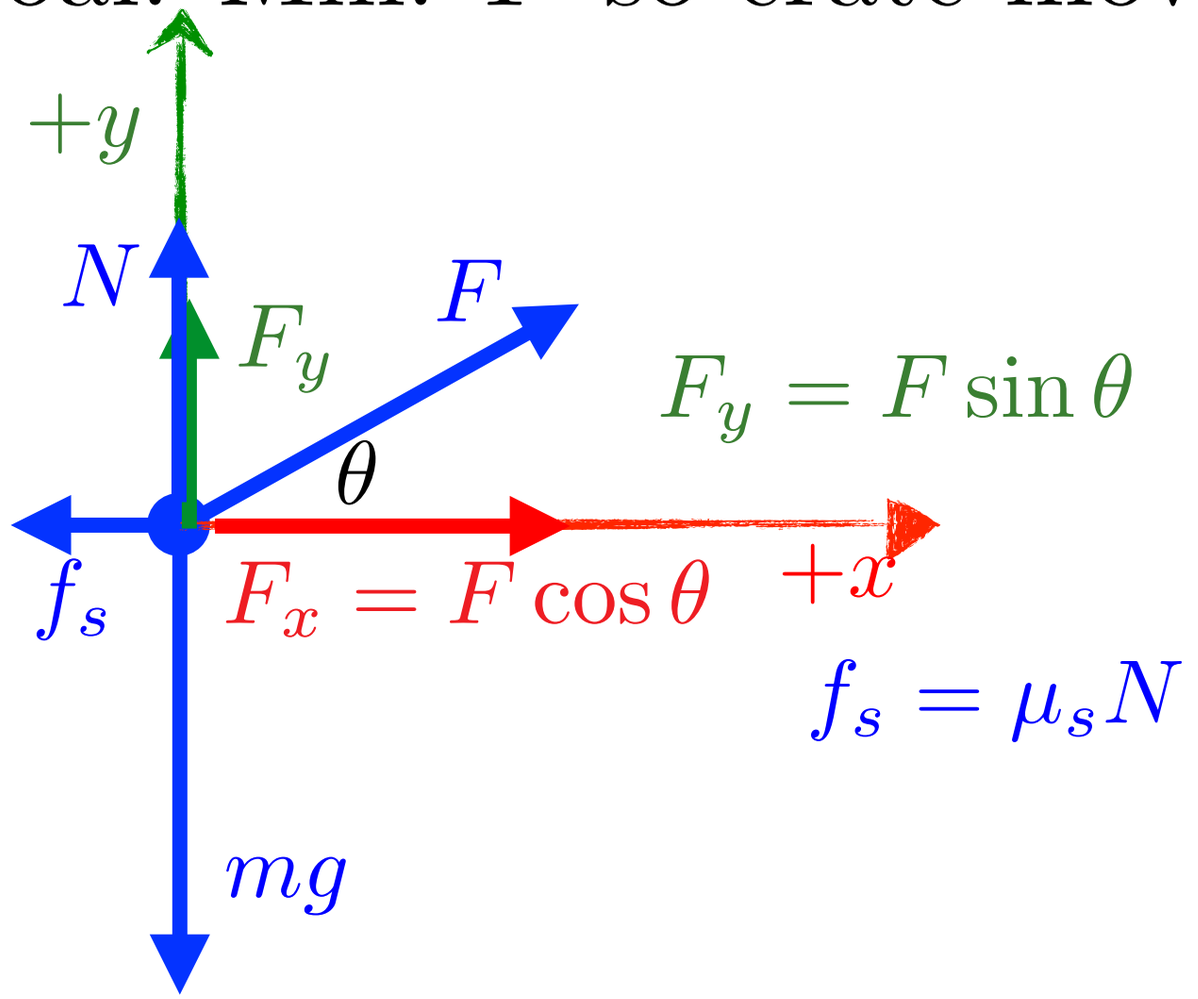
Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate

$$N + F\sin\theta - mg = 0$$



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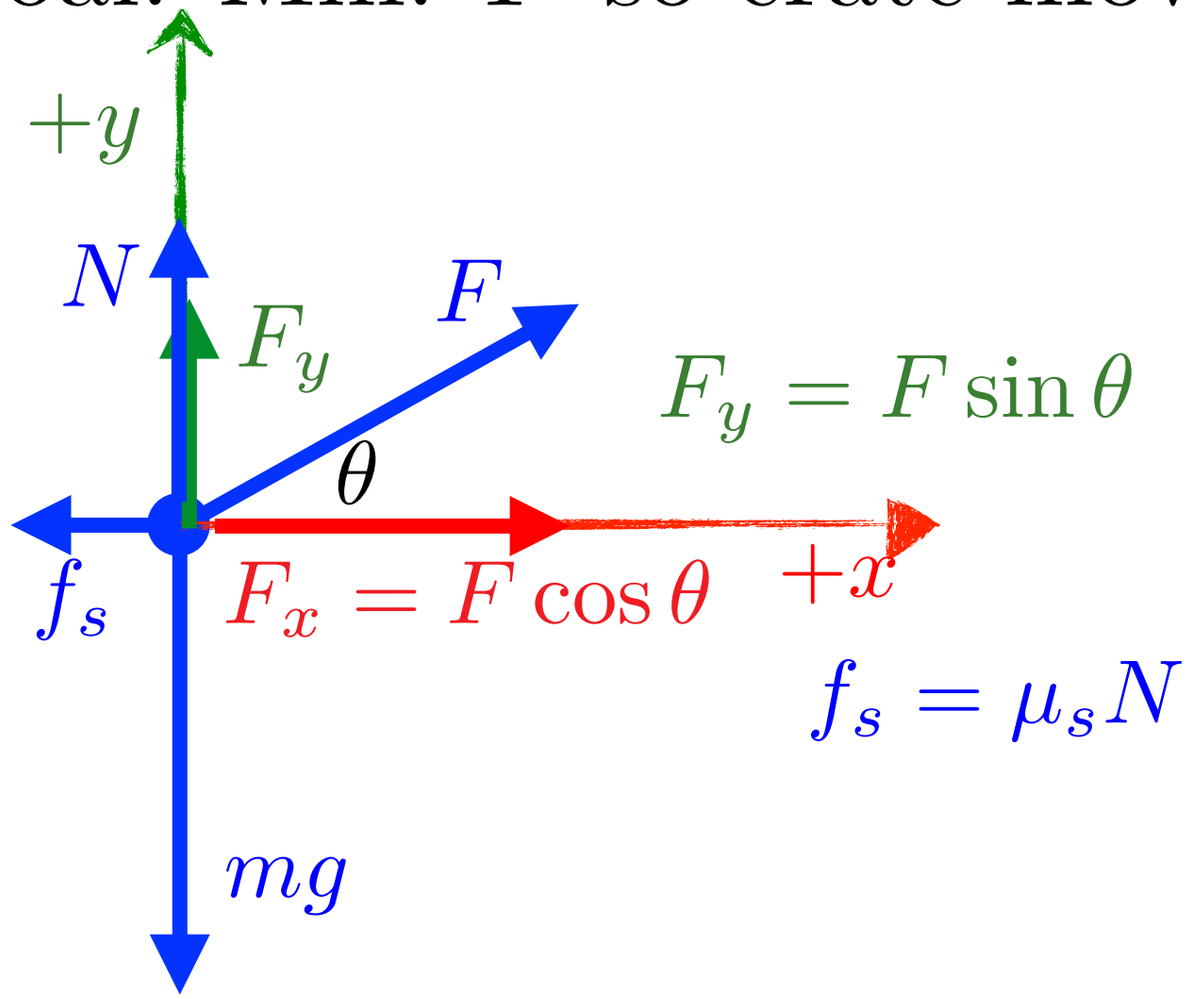

$$N + F\sin\theta - mg = 0$$

$$N = mg - F\sin\theta$$

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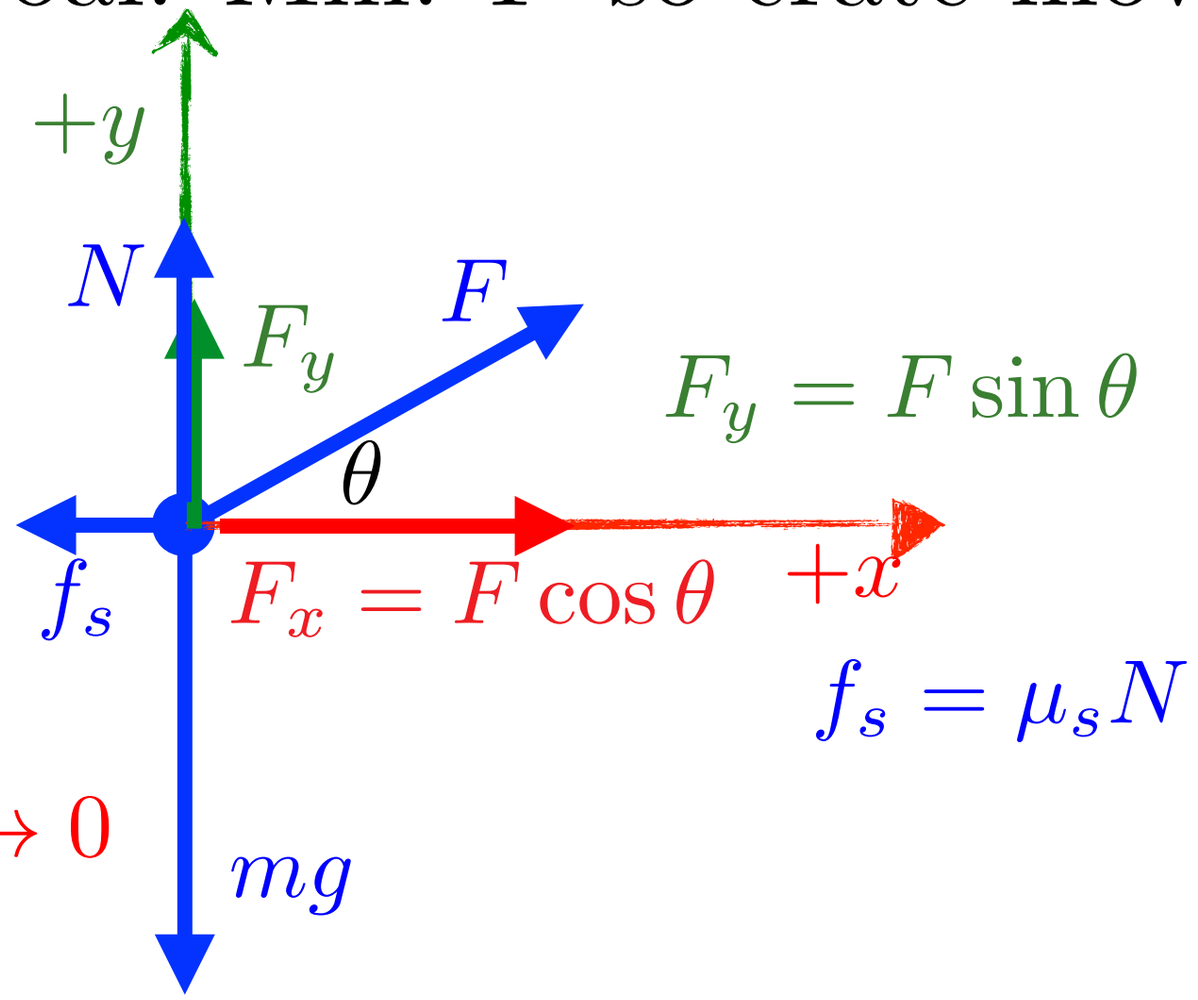
Goal: Min. F so crate moves

5. Calculate



$$N + F\sin\theta - mg = 0$$

$$N = mg - F\sin\theta$$

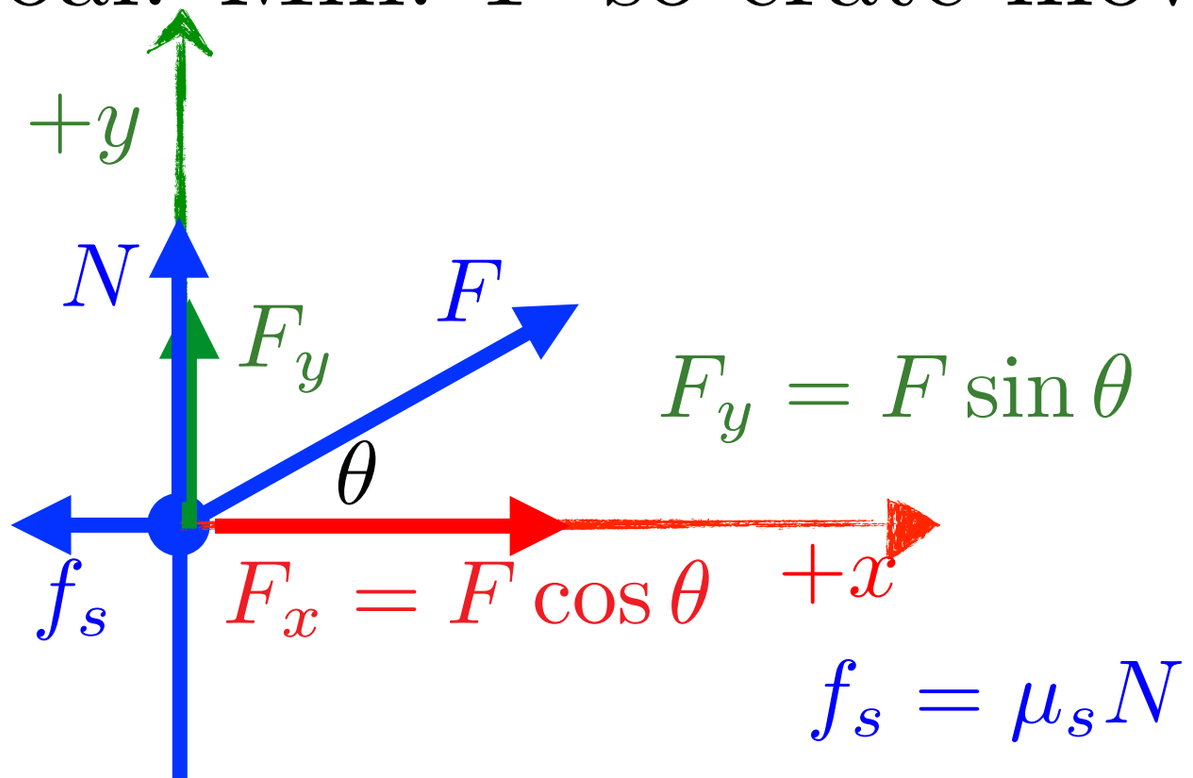
$$F\cos\theta - f_s = ma \to 0 \text{ as } a \to 0$$

Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate



$$N + F\sin\theta - mg = 0$$

$$N = mg - F\sin\theta$$

$$F\cos\theta - f_s = ma \to 0 \text{ as } a \to 0$$

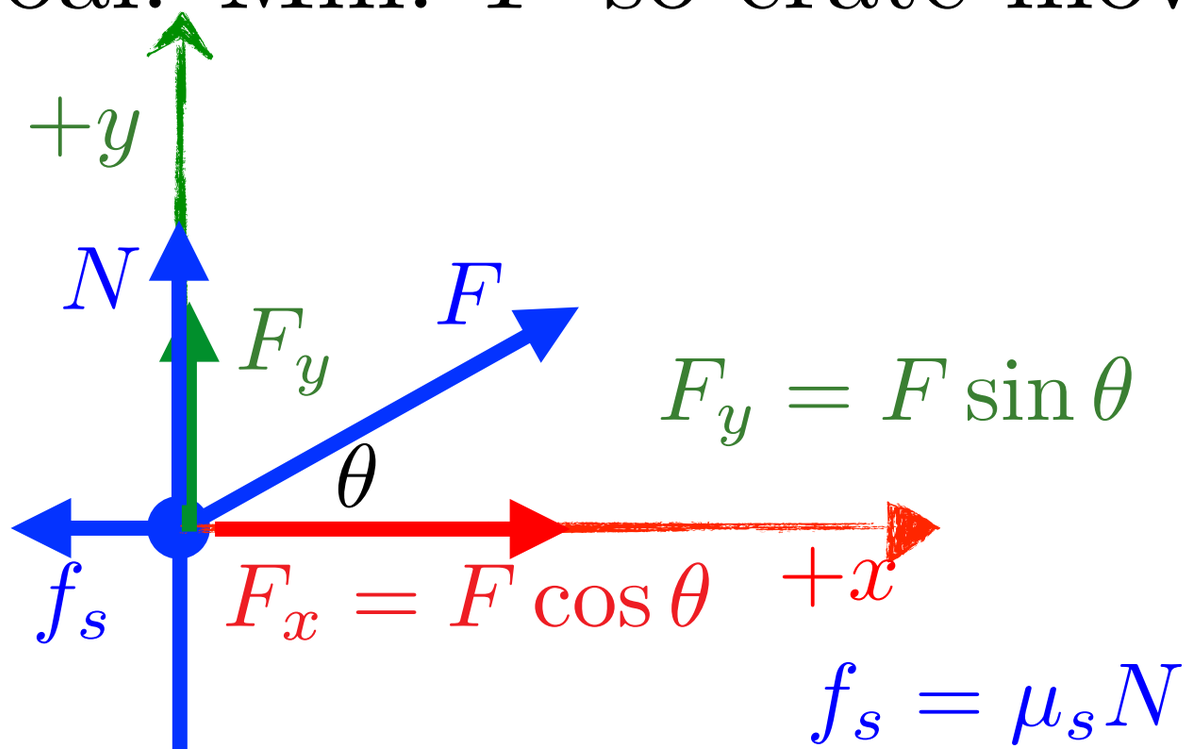
$$F\cos\theta - \mu_s N = 0$$

Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate



$$N + F\sin\theta - mg = 0$$

$$N = mg - F\sin\theta$$

$$F\cos\theta - f_s = ma \to 0 \text{ as } a \to 0$$

$$F\cos\theta - \mu_s N = 0$$

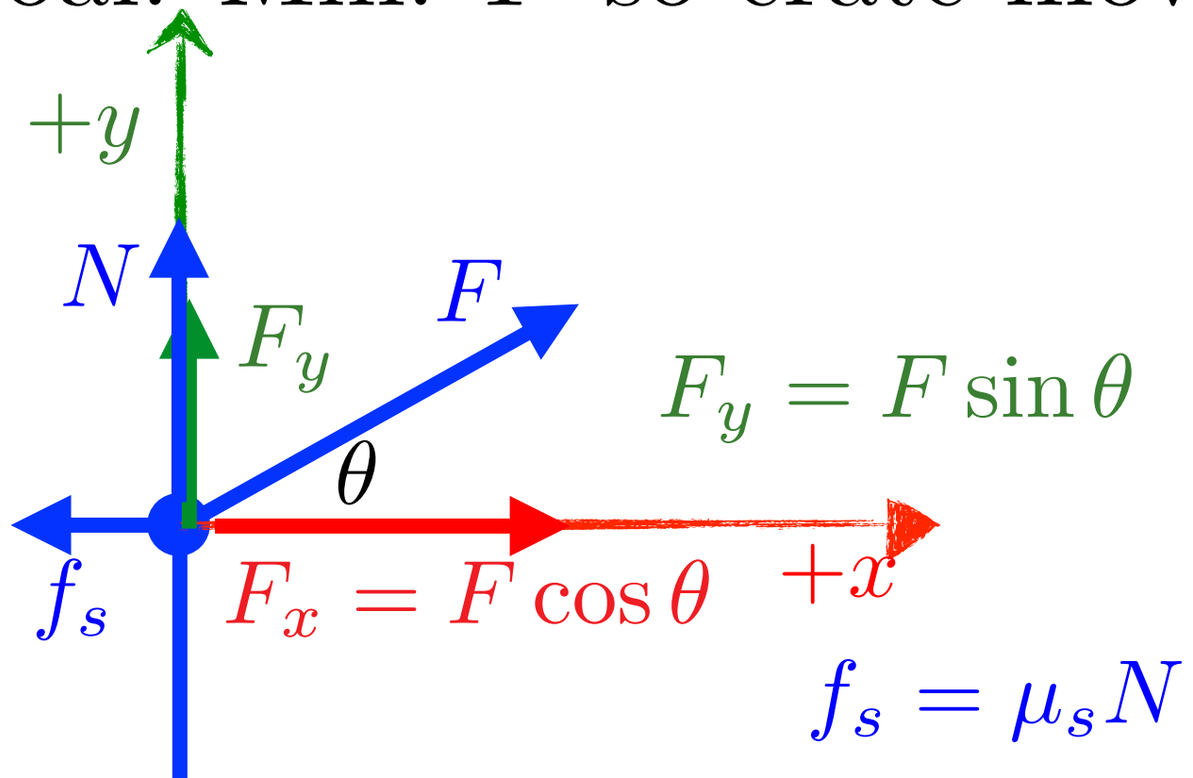
$$F\cos\theta - \mu_s mg + \mu_s F\sin\theta = 0$$

Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate



$$N + F\sin\theta - mg = 0$$

$$N = mg - F\sin\theta$$

$$F\cos\theta - f_s = ma \to 0 \text{ as } a \to 0$$

$$F\cos\theta - \mu_s N = 0$$

$$F\cos\theta - \mu_s mg + \mu_s F\sin\theta = 0$$

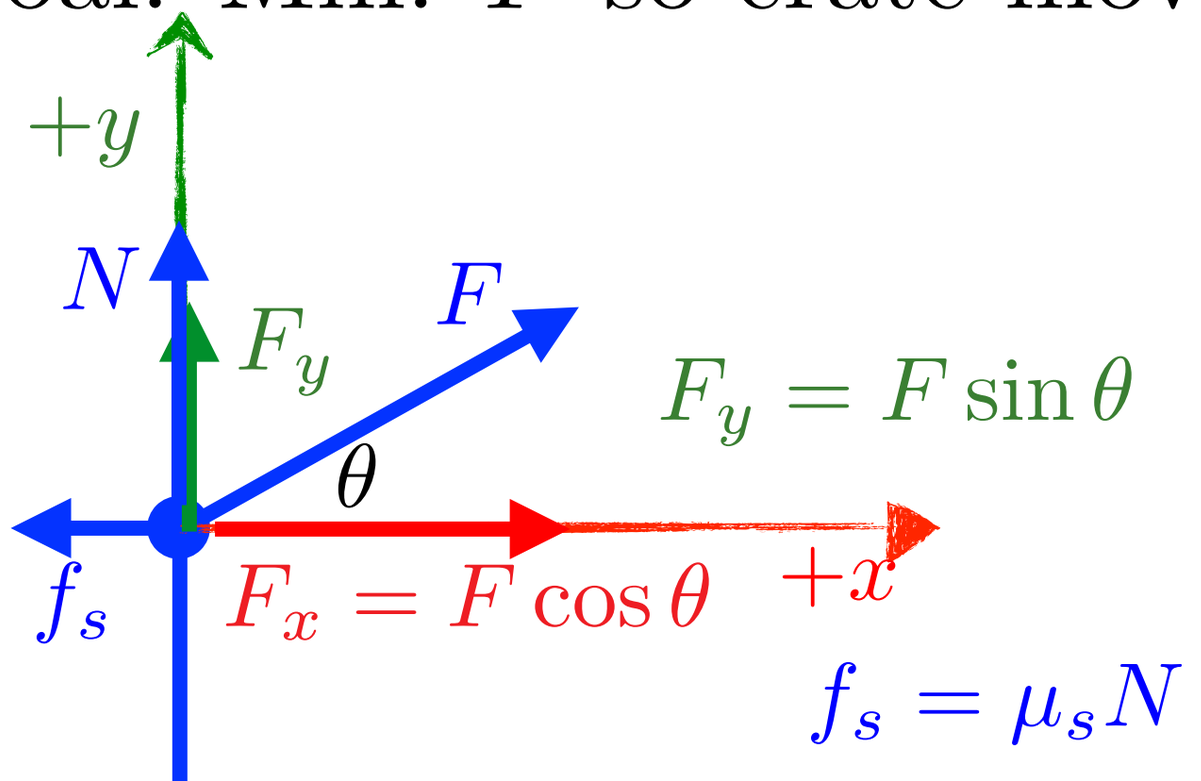
$$F\left(\cos\theta + \mu_s \sin\theta\right) = \mu_s mg$$

Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate



$$N + F\sin\theta - mg = 0$$

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$$F\cos\theta - f_s = ma \to 0 \text{ as } a \to 0$$

$$F\cos\theta - \mu_s N = 0$$

$$F\cos\theta - \mu_s mg + \mu_s F\sin\theta = 0$$

$$F\left(\cos\theta + \mu_s \sin\theta\right) = \mu_s mg$$

$$F = \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta}$$

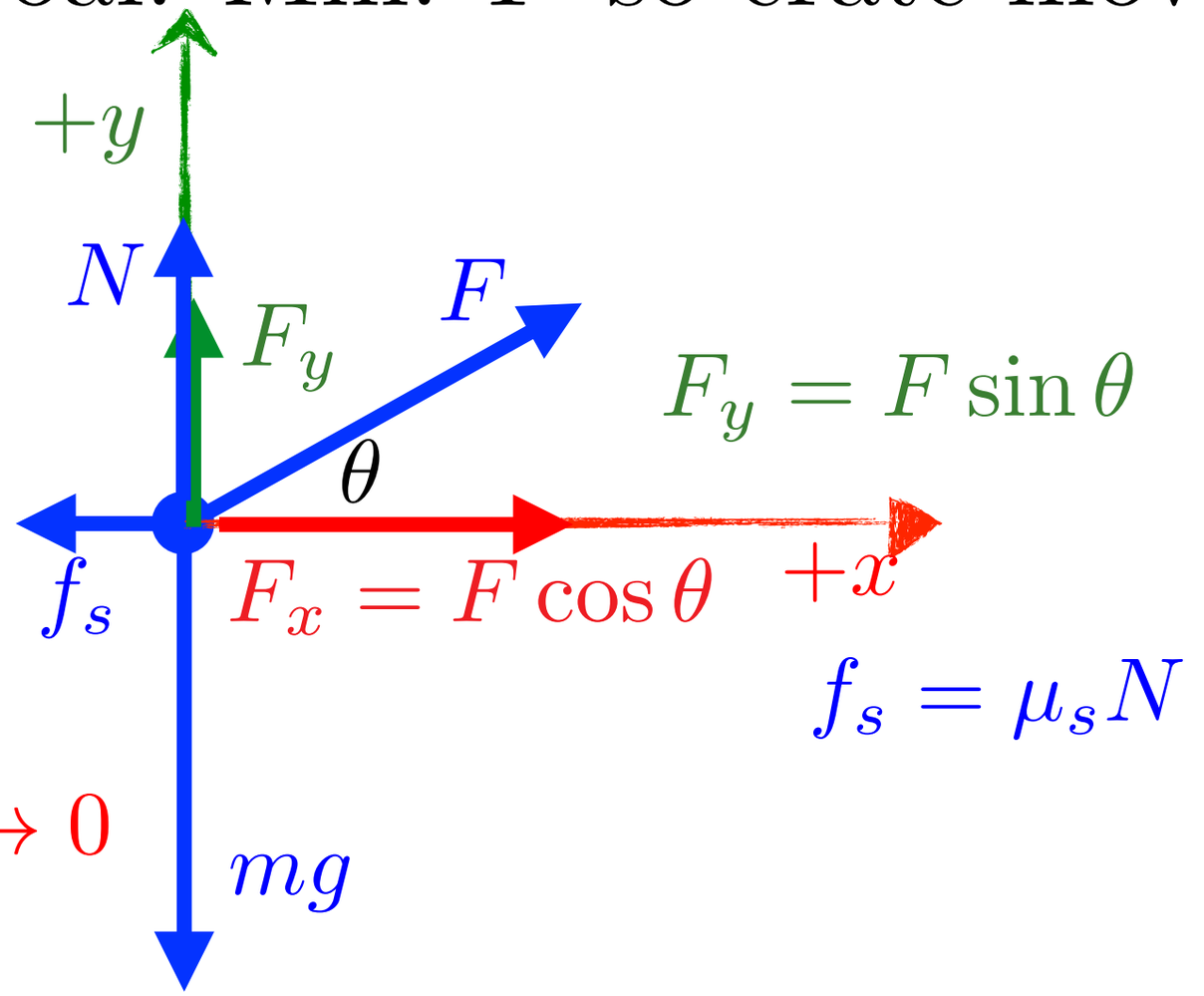
Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate

(6. Plug in numbers)



$$N + F\sin\theta - mg = 0$$

$$N = mg - F\sin\theta$$

$$F\cos\theta - f_s = ma \to 0 \text{ as } a \to 0$$

$$F\cos\theta - \mu_s N = 0$$

$$F\cos\theta - \mu_s mg + \mu_s F\sin\theta = 0$$

$$F\left(\cos\theta + \mu_s \sin\theta\right) = \mu_s mg$$

$$F = \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta}$$

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Given: $\theta = 30^\circ$, μ_s, m, g

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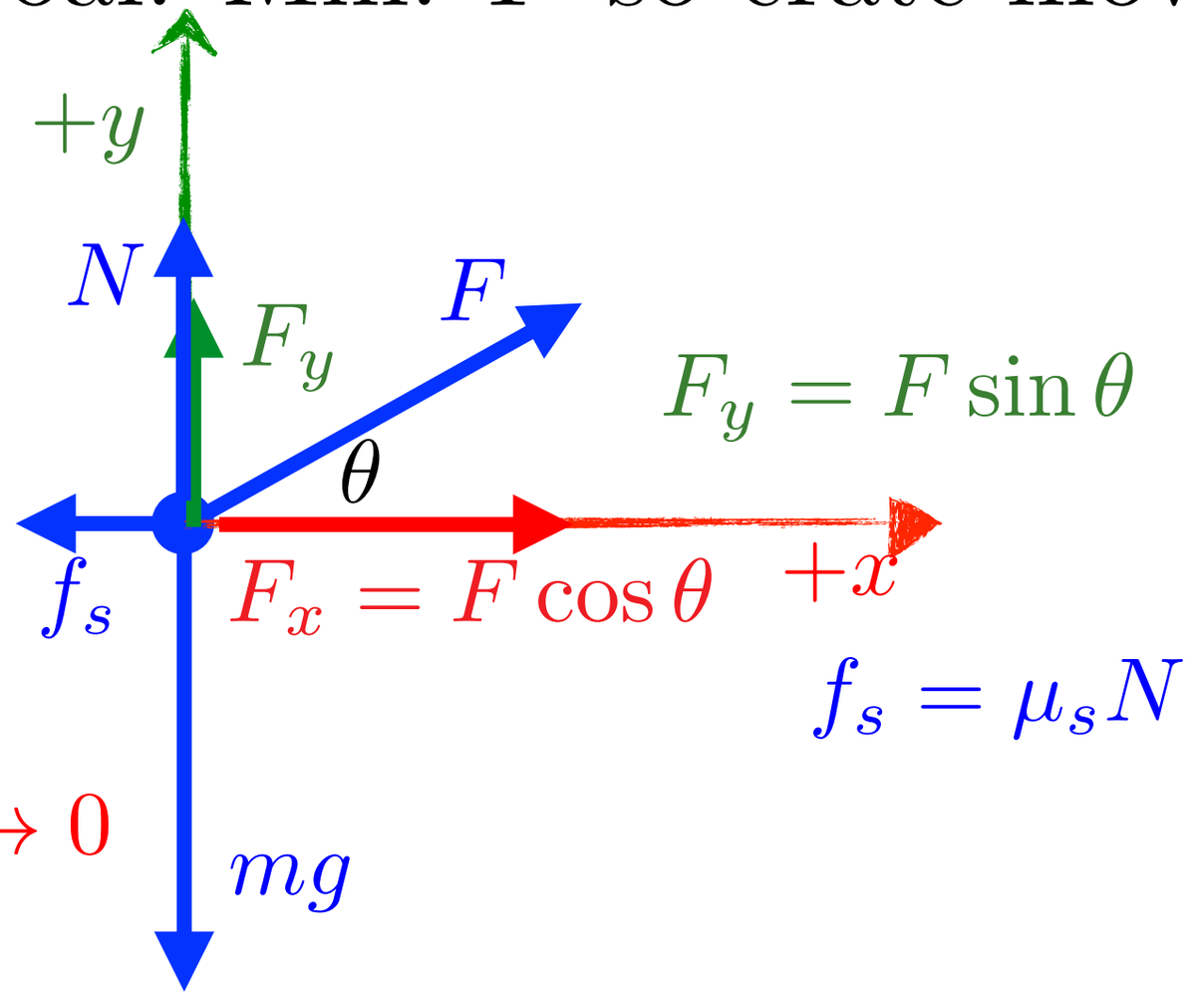

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$$F\cos\theta - \mu_s N = 0$$

$$F\cos\theta - \mu_s mg + \mu_s F\sin\theta = 0$$

$$F\left(\cos\theta + \mu_s \sin\theta\right) = \mu_s mg$$

$$F = \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta}$$

$$\mu_s = 0.650$$

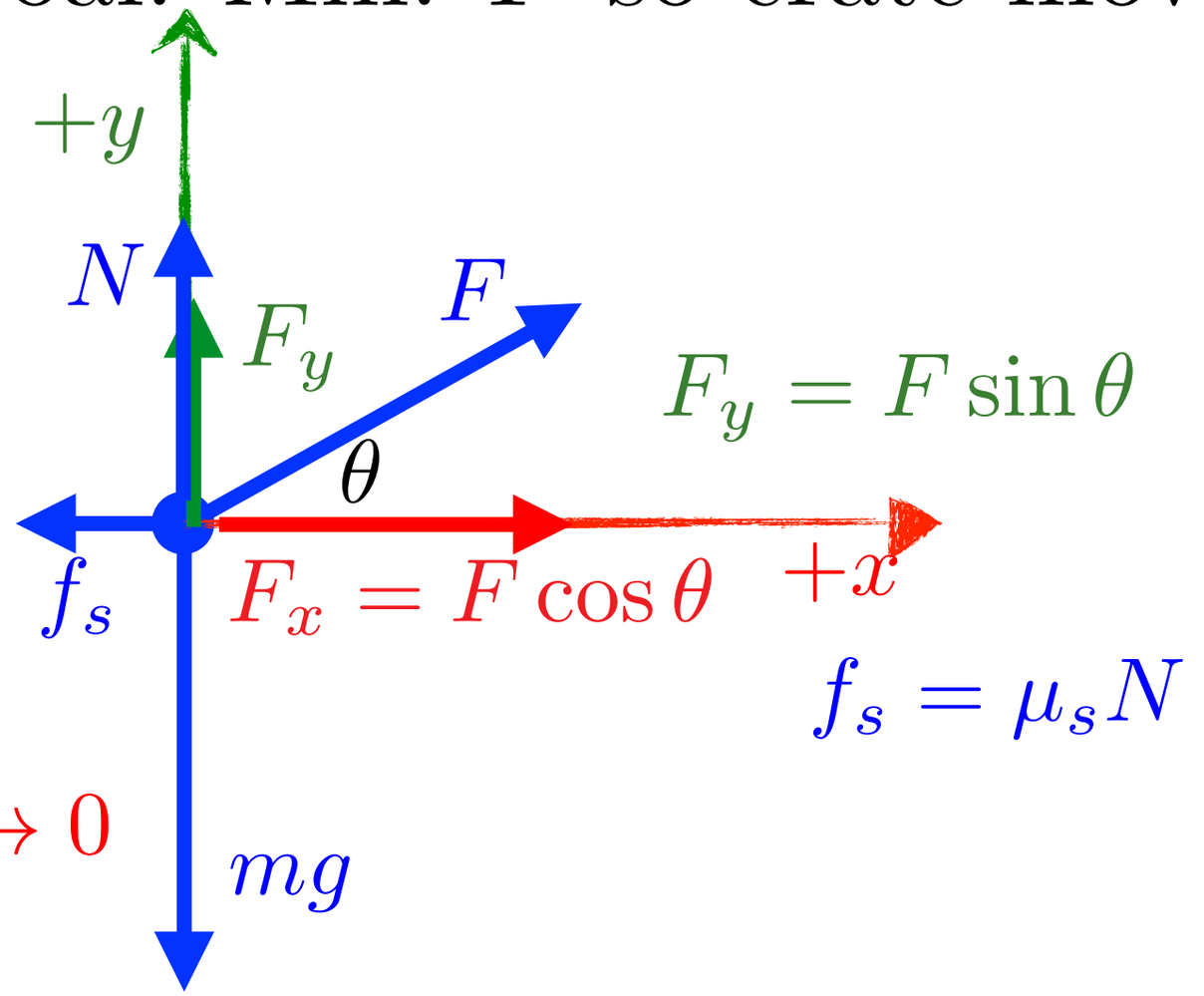
Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate

(6. Plug in numbers)



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$$F\left(\cos\theta + \mu_s \sin\theta\right) = \mu_s mg$$

$$F = \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta}$$

$\mu_s = 0.650$

$m = 40$ kg

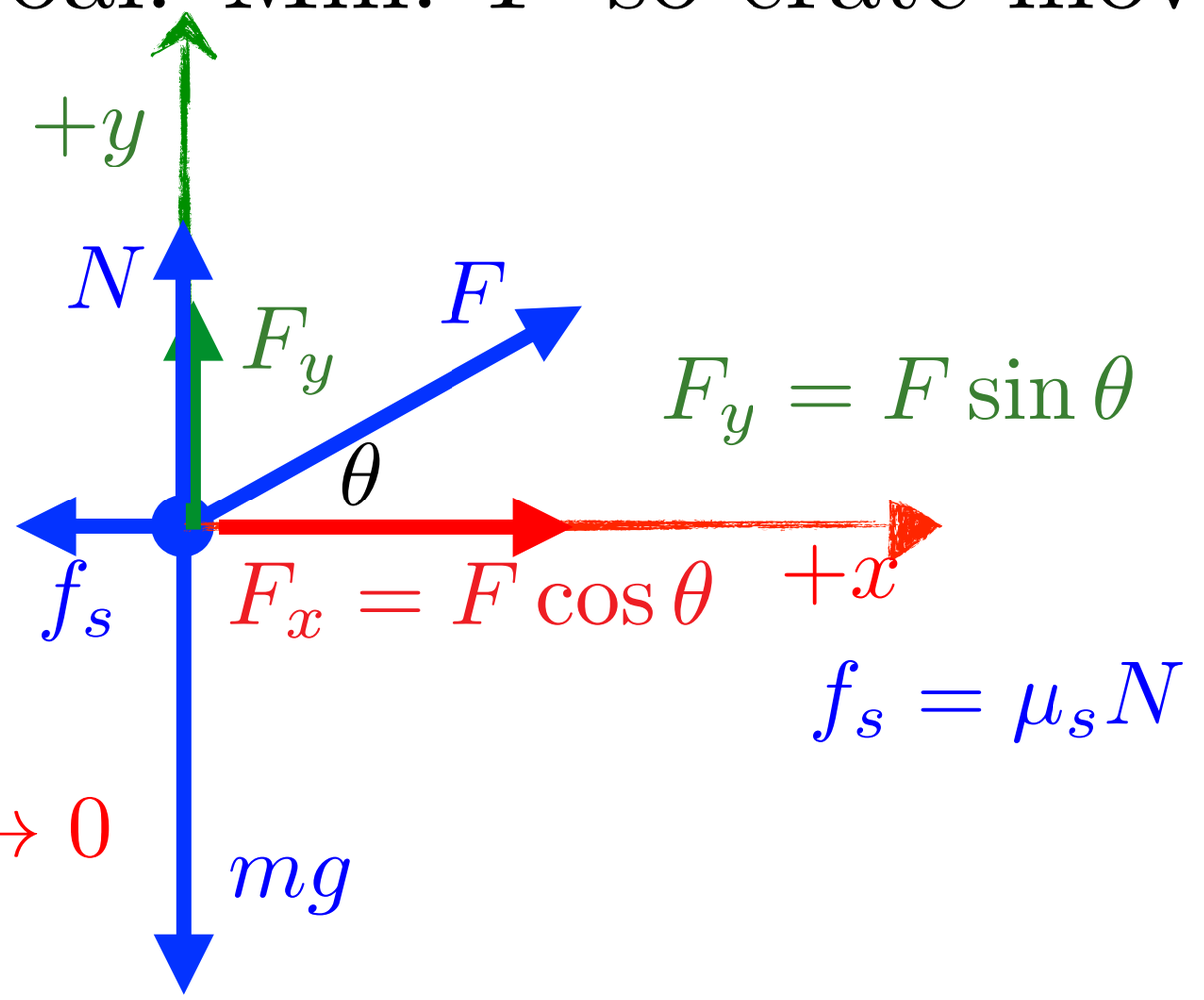
Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate

(6. Plug in numbers)



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$$F\left(\cos\theta + \mu_s \sin\theta\right) = \mu_s mg$$

$$F = \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta}$$

$\mu_s = 0.650$

$m = 40$ kg

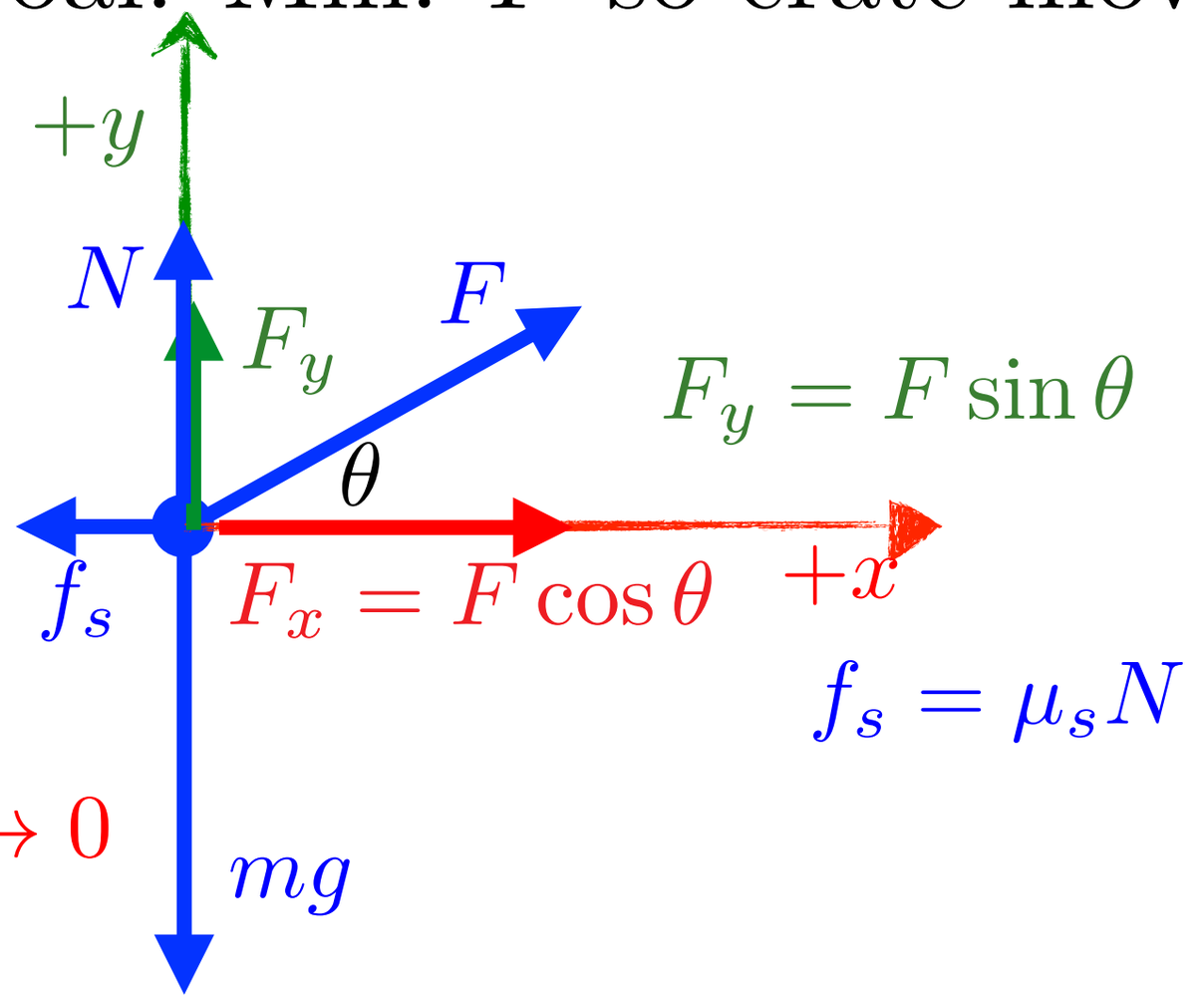
$F = 214$ N (vs. 255 N for $\theta = 0$)

Ex. 4.10

Given: $\theta = 30^\circ$, μ_s, m, g

Goal: Min. F so crate moves

5. Calculate
(6. Plug in numbers)
7. Is answer reasonable?



$$N + F\sin\theta - mg = 0$$

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