Good morning!

Tomorrow is on Monday's schedule (=> Lab4)!

IF the lecture ends early, the rest of the time = Q&A

Please, sign in, login into webassing, locate LectureMCQ_L7 (PY105) and answer question 1 (but ONLY Q1 !)

NOTE: Exam 1 is on Monday, June 4, 8:30 – 10:30 am, in LSE B01

Hint: arrive ~ 8-15

Lab4 is in SCI 134

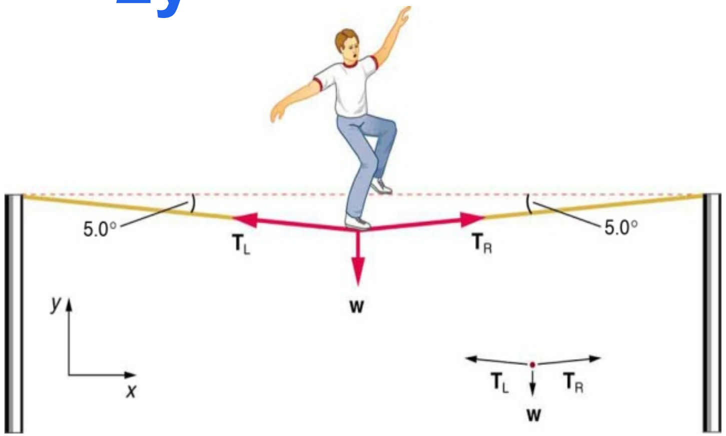
When forces are acting on an object =>

(A) Equilibrium

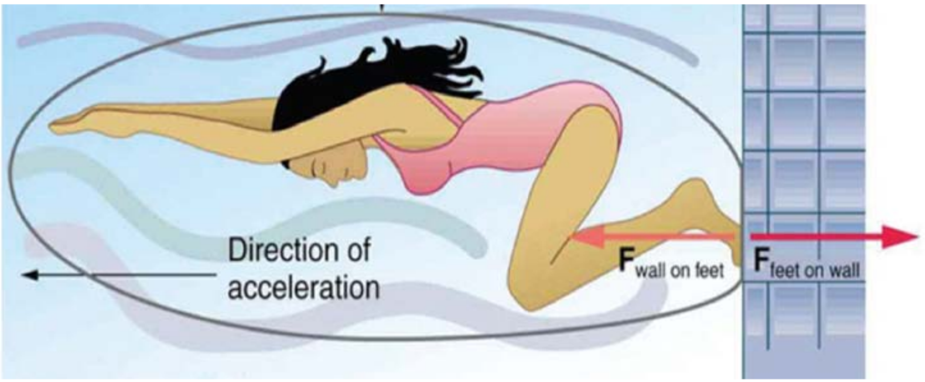
$\vec{F}_{net} = 0$ (and $\vec{v} = 0$)

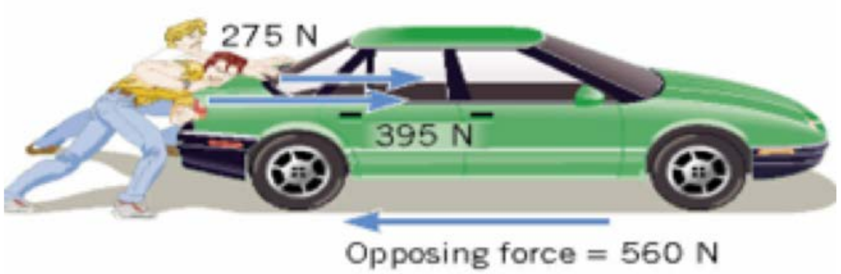
$F_{1x} + F_{2x} + \ldots = 0$

$F_{1y} + F_{2y} + \ldots = 0$

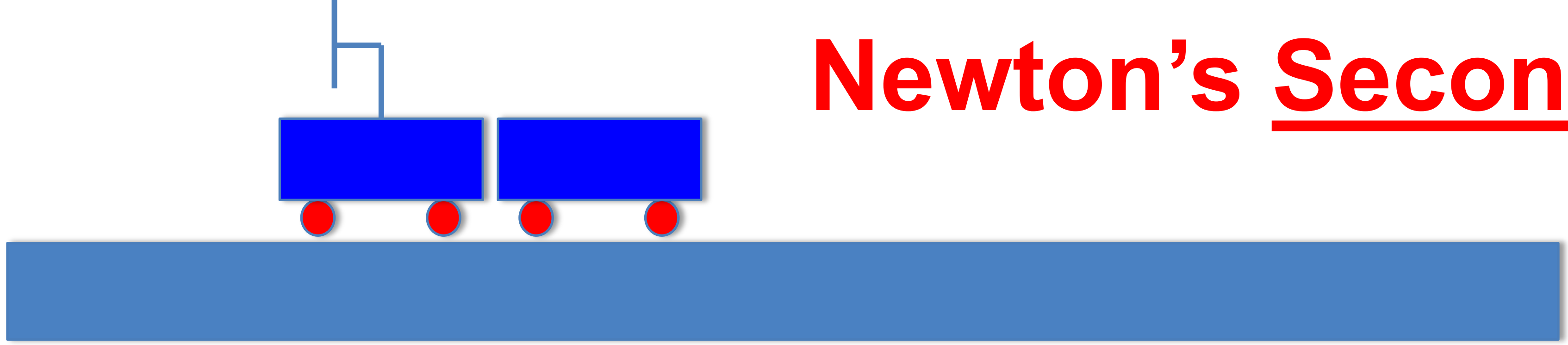


(B) $\vec{F}_{net} \neq 0$

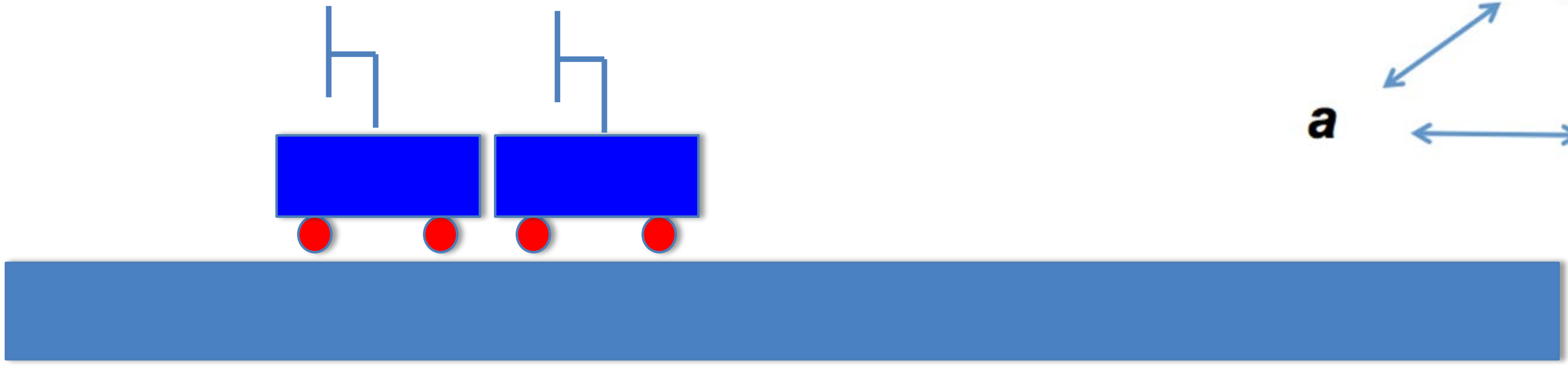


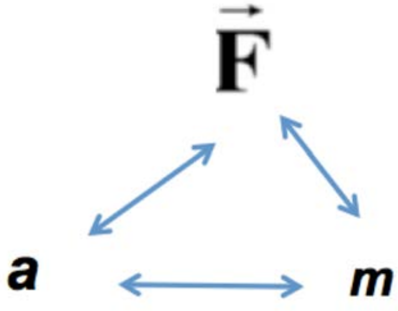


Newton's Second Law



vs.

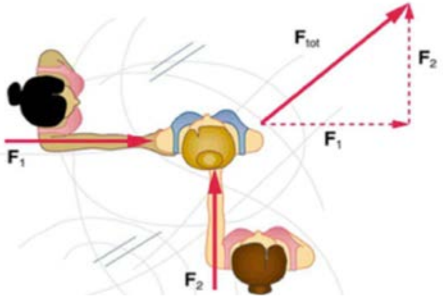




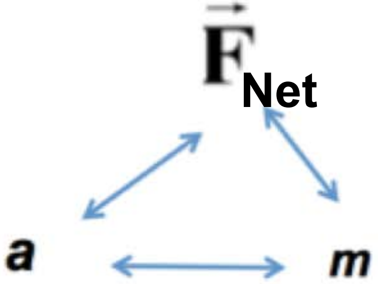
$$a \propto F \qquad a \propto \frac{1}{m}$$

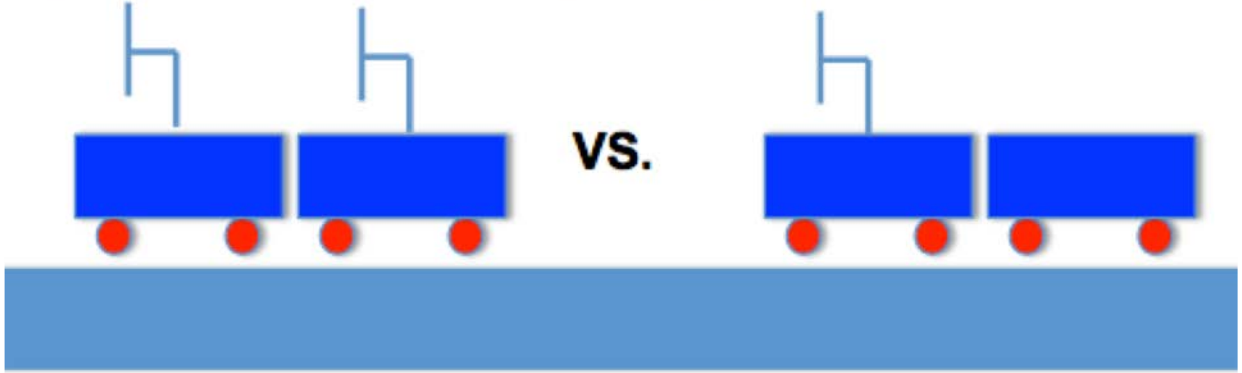
$$\sum \vec{F} = \vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots$$

N2L

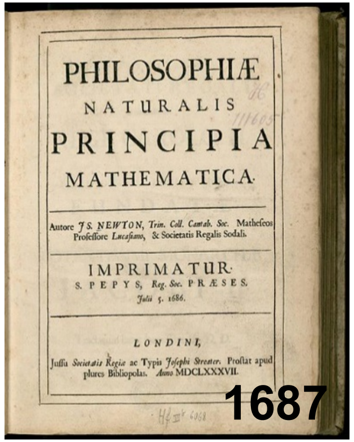


$$\vec{a} = \frac{\sum \vec{F}}{m}$$





$$a \propto F \qquad a \propto \frac{1}{m}$$


PHILOSOPHIÆ
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Julii 5. 1686.

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1687

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots$$

Some of the Mechanical Forces:

1. Gravity; close to the Earth $|F_g| = m \cdot g$
2. Normal force; N = force acting from the support perpendicularly to the surface of the support
3. Tension; T = force in a rope/string (an applied force; a pull)
4. Elastic: $|F_e| = k \cdot |\Delta x|$
5. A push – an applied force

The Newton's Second Law (N2L)

$$\vec{a} = \frac{\sum \vec{F}}{m}$$

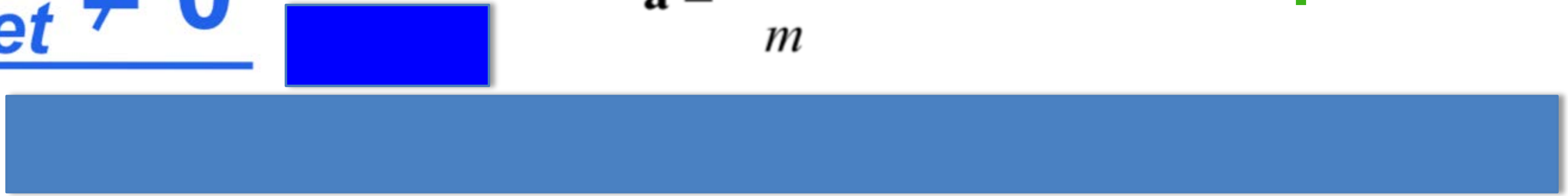
$$m\vec{a} = \vec{F}_{Net}$$

The acceleration of an object (a.k.a. *system*) is equal to the net force acting on the object divided by the mass of the object.

$\vec{F}_{net} \neq 0$

$$\vec{a} = \frac{\sum \vec{F}}{m}$$

Non-Equilibrium

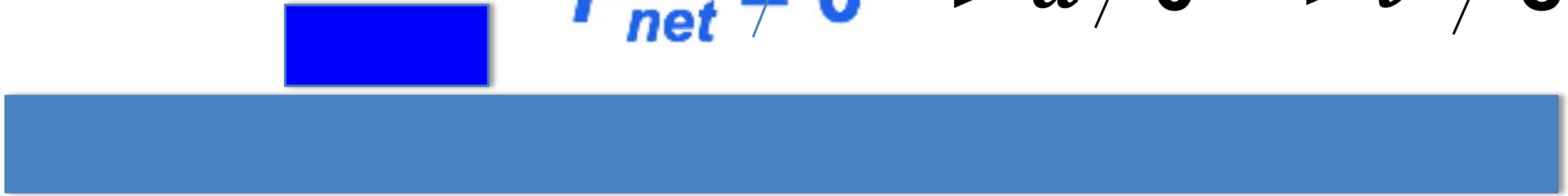


vs.

$\vec{F}_{net} = 0$ but $v \neq 0$

Non-Equilibrium

$$\vec{F}_{net} \neq 0 \;\Rightarrow\; \vec{a} \neq 0 \;\Rightarrow\; \vec{v} \neq const$$



$$\vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m}$$

vs.

$$\vec{F}_{net} = 0 \;\Rightarrow\; \vec{a} = 0 \;\Rightarrow\; \vec{v} = const$$

Newton's <u>First</u> Law

An object does NOT need a force in order to be kept at rest or in a state of a linear motion with a constant velocity.

$\vec{a}$

In order to *change its velocity* an object must be under action of at least one an uncompensated force. → $\vec{F}$

Topics for the first three weeks (do NOT read this slide!)

a scalar, a vector, a component, a right triangle, sin, cos, tan, the Pythagorean theorem, Coordinate system, Cartesian coordinate system, an axis, an origin, a coordinate, Cartesian vector components, linear equation, quadratic equation, quadratic formula, a unit, fundamental (base) units, SI system of units, unit conversion, conversion factor, prefix words, etalon/standard, measurement, Motion, 1 D motion, 2 D motion, translational motion, linear motion (LM), position, position vector, displacement, distance, elapsed time, velocity, speed, average velocity, average speed, instantaneous velocity, motion equation, motion diagram, position graph, velocity graph, meaning of the slope, meaning of the area, constant velocity motion (CVM), properties of CVM, acceleration, average acceleration, instantaneous acceleration, motion with constant acceleration (MCA), properties of MCA, relative motion, velocity addition, "crossing the river", projectile motion (PM), properties of PM, range, maximum height, flight time, Force, N2L.

Exam I

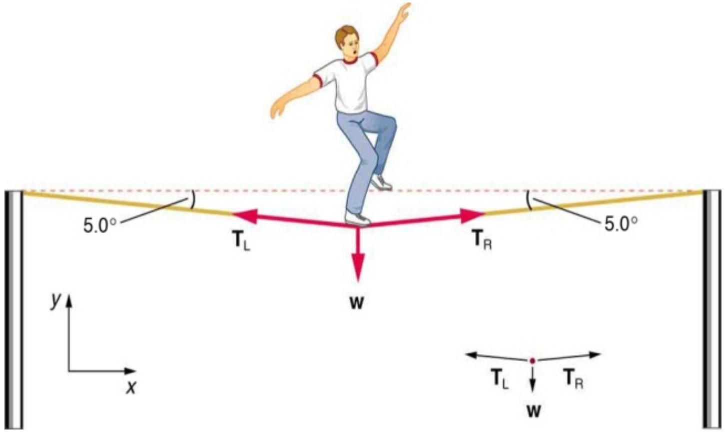
"DONE!"

(A) Equilibrium

$\vec{F}_{net} = 0$ (and $\vec{v} = 0$)

$F_{1x} + F_{2x} + \ldots = 0$

$F_{1y} + F_{2y} + \ldots = 0$



I. Proving the condition

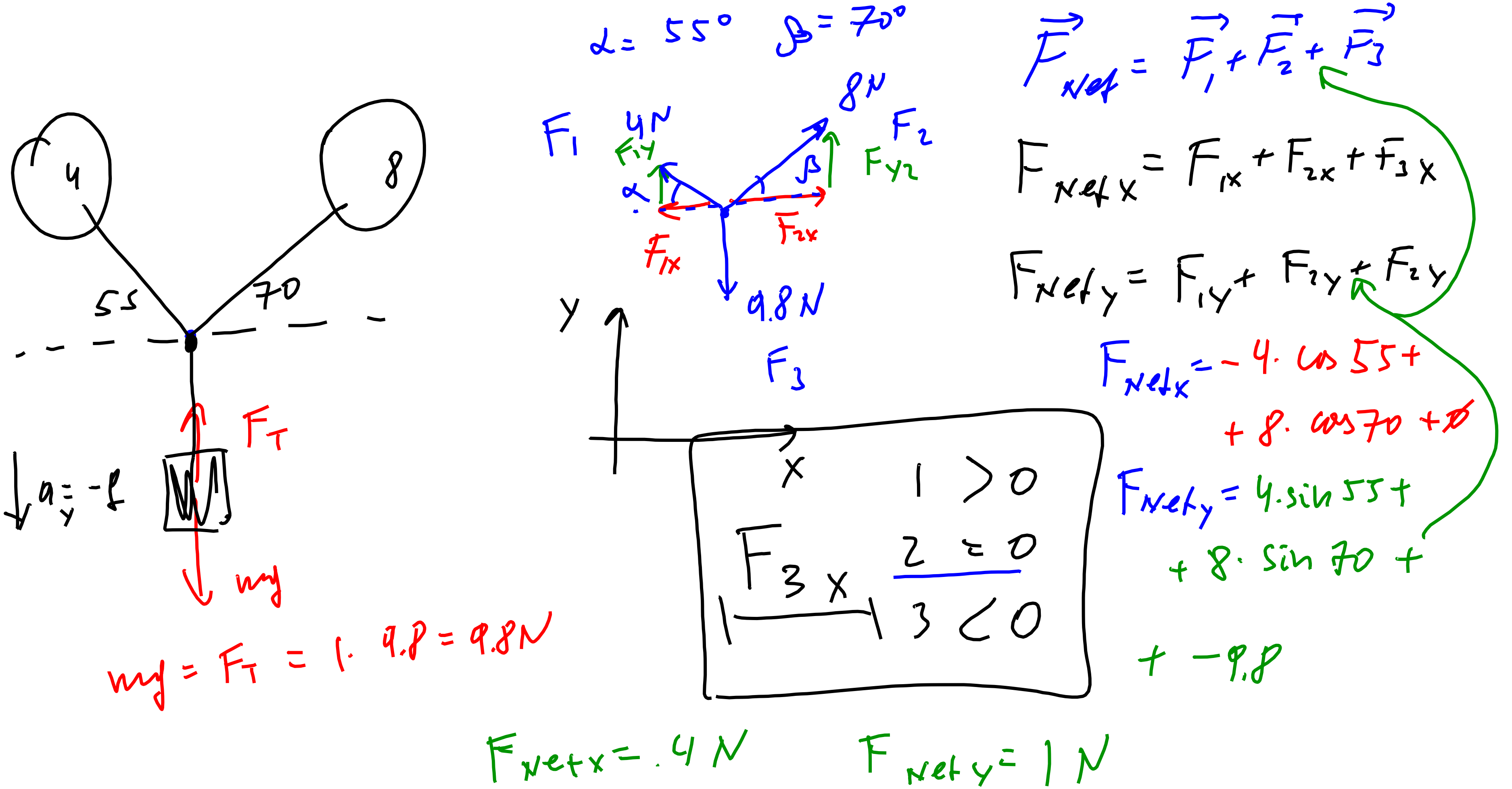
II. Using the condition

http://www.wolframalpha.com/

http://www.wolframalpha.com/examples/mathematics/plotting-and-graphics/

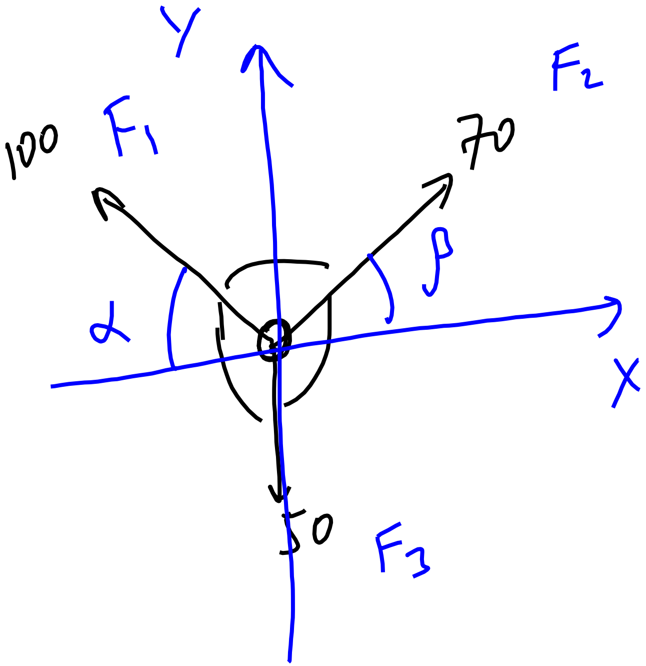
LectureMCQ_L7 Q2

I. Proving the condition



Both components are close to zero = > the net force is practically zero!

II. Using the condition



$$\vec{F}_{net} = 0$$

$$x: \; -100 \cdot \cos\alpha + 70 \cdot \cos\beta + 0 = 0$$

$$y: \; 100 \cdot \sin\alpha + 70 \sin\beta - 50 = 0$$

$$\alpha, \beta = ?$$

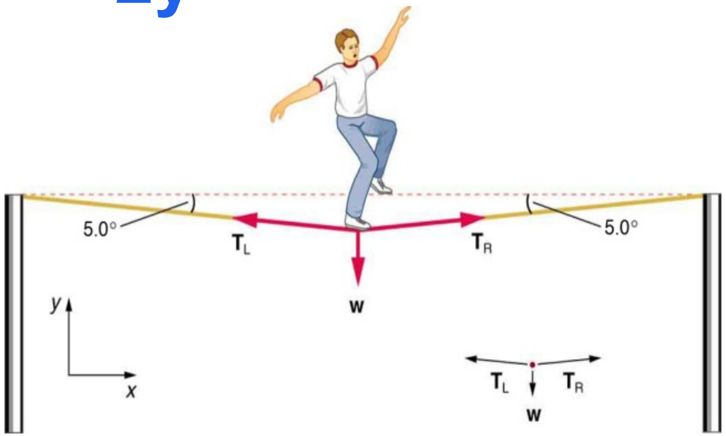
http://www.wolframalpha.com/

(A) Equilibrium

$\vec{F}_{net} = 0$ (and $\vec{v} = 0$)

$F_{1x} + F_{2x} + \ldots = 0$

$F_{1y} + F_{2y} + \ldots = 0$



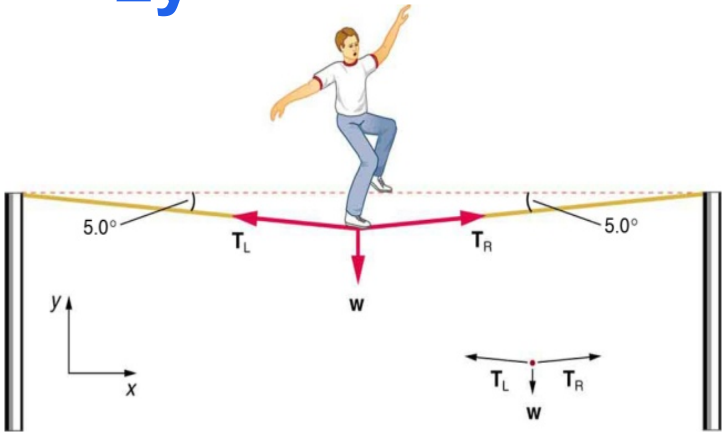
How **can** we select the directions of the x- and y- axes?

(A) Equilibrium

$\vec{F}_{net} = 0$ (and $\vec{v} = 0$)

$F_{1x} + F_{2x} + \ldots = 0$

$F_{1y} + F_{2y} + \ldots = 0$



How **can** we select the directions of the x- and y- axes?

Anyhow!

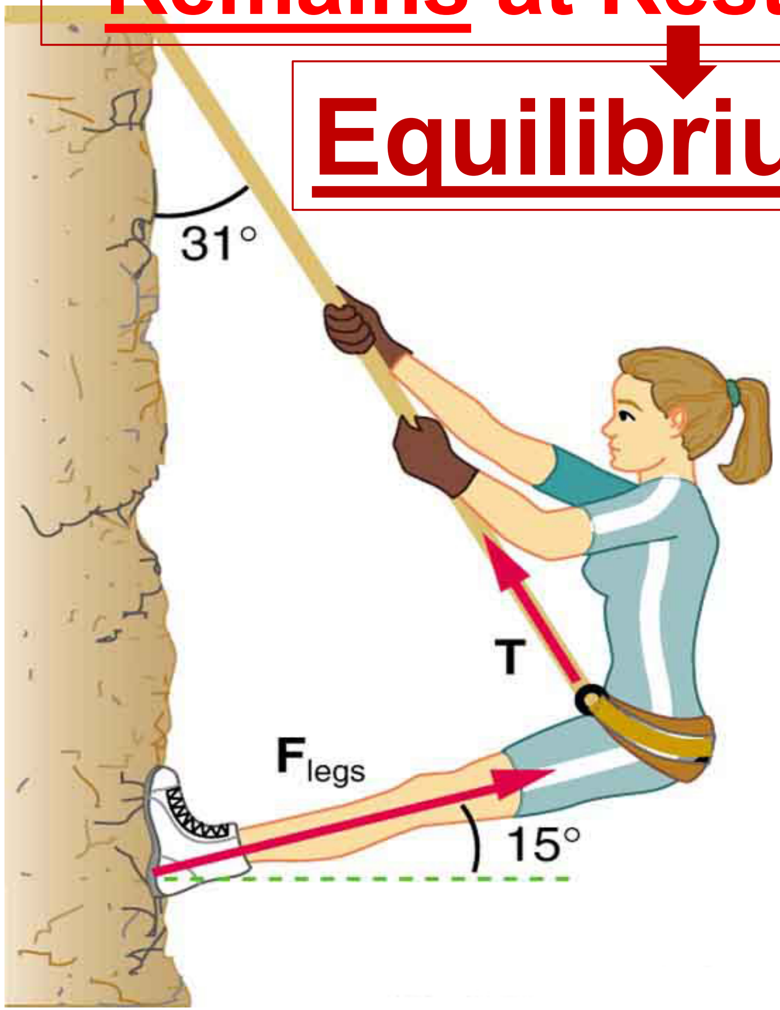
Whatever we like!

Drawing FBD and writing N2L

"Remains at Rest" =>

Equilibrium

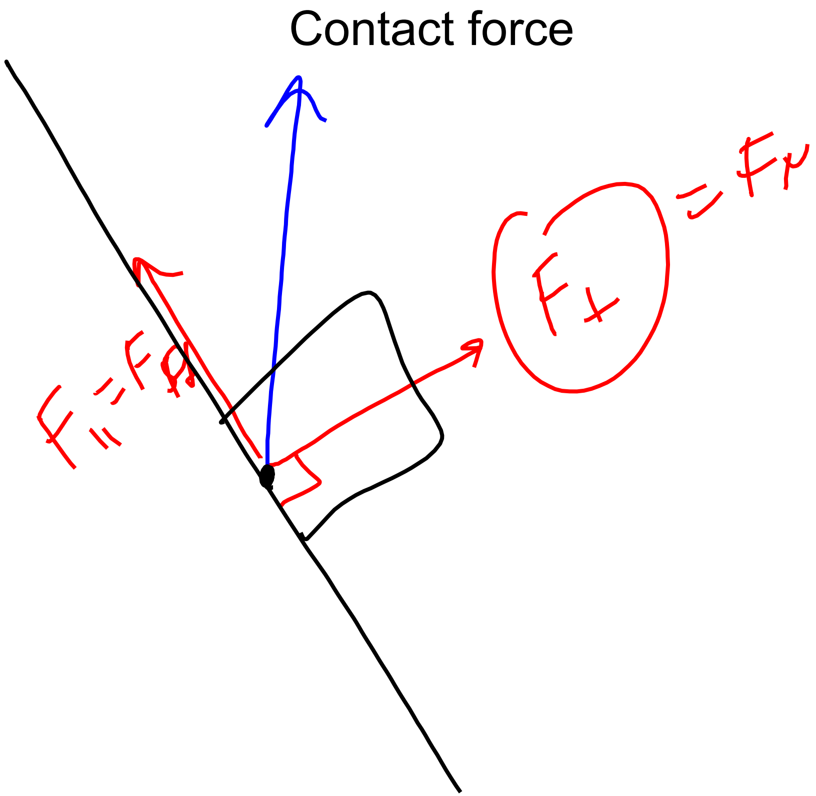
$\vec{v} = 0 \;\; => \;\; \vec{F}_{NET} = 0$



A part of the climber's weight is supported by her rope and a part - by the friction between her feet and the rock face.

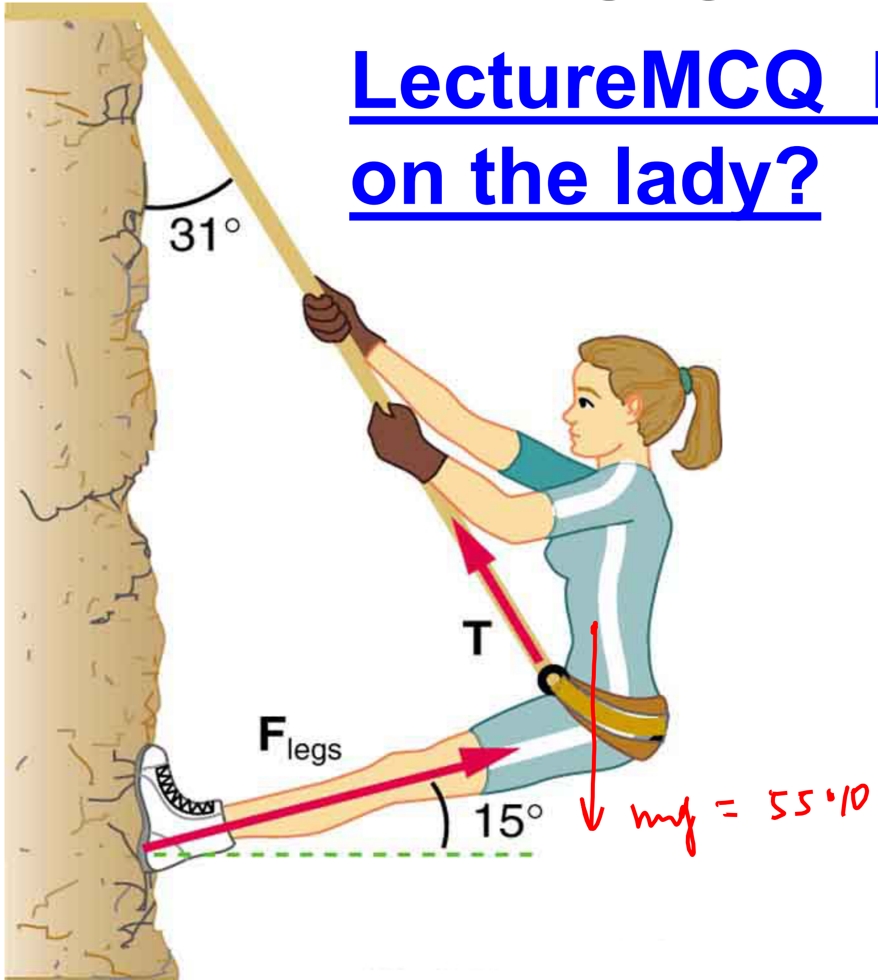
Set: m = 55 kg, g = 10 m/s^2.

Find the forces.


Contact force

A part of the climber's weight is supported by her rope and a part - by the friction between her feet and the rock face.

Set: m = 55 kg, g = 10 m/s^2. Find the forces.

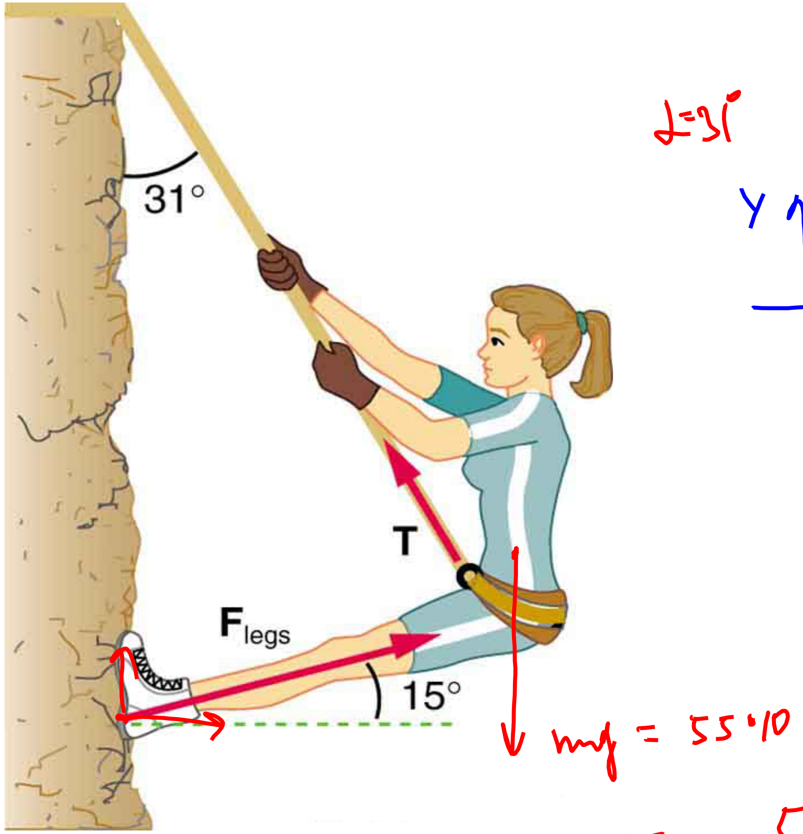


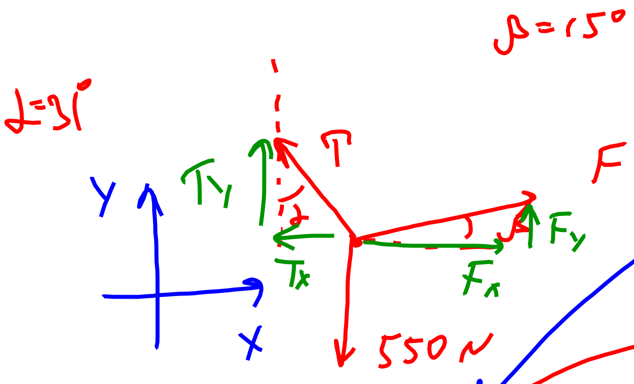
LectureMCQ L7 Q3: how many forces act on the lady? Draw FBD!!

3 forces!

Set: m = 55 kg, g = 10 m/s^2. Find the forces.

How *can* we select the direction of the x- and y- axes?





x: $T_x + F_x + mg_x = 0$

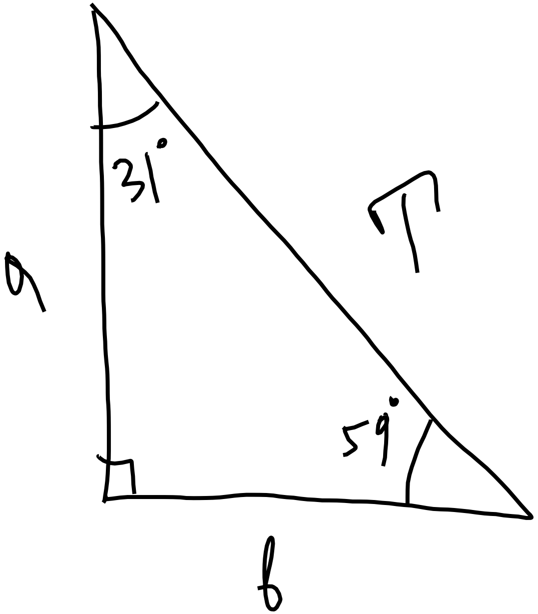
$-T\cdot\sin 31 + F\cdot\cos 15 + 0 = 0$

y: $T\cdot\cos 31 + F\cdot\sin 15 - 550 = 0$

$$T = F\frac{\cos 15}{\sin 31};$$

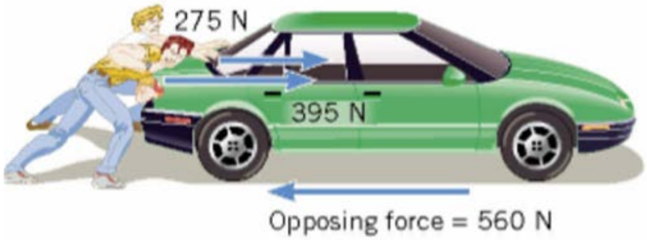
$$F\cdot\frac{\cos 15}{\sin 31}\cdot\cos 31 + F\cdot\sin 15 = 550$$

$$F = 550\Big/\left(\frac{\cos 15}{\sin 31}\cdot\cos 31 + \sin 15\right) = \ldots$$

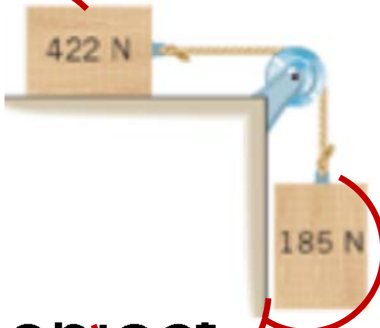


ANY angle

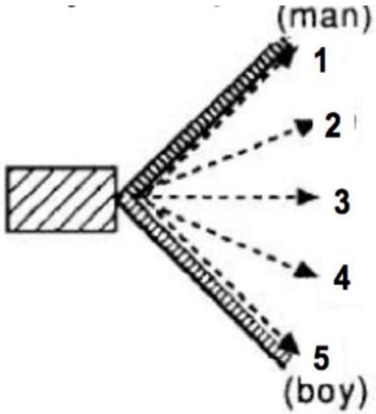
Newton's Second Law of Motion



Investigating Newton's Second Law



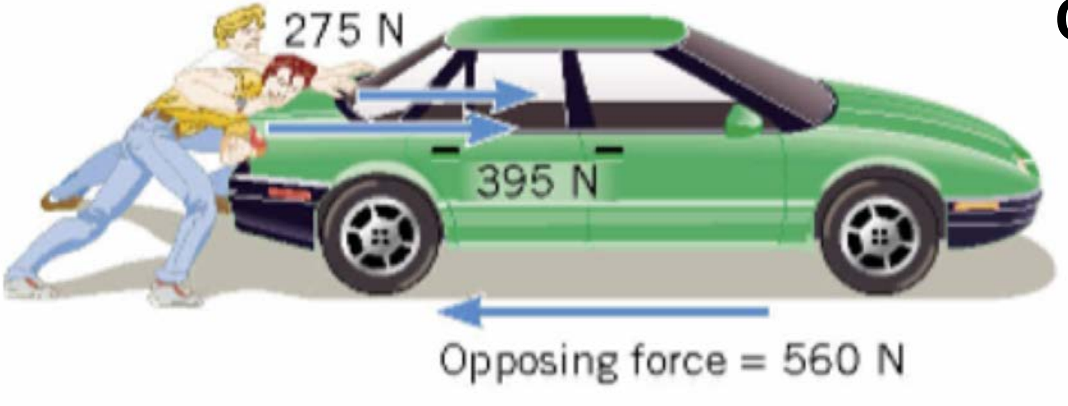
When a net external force acts on an object of mass *m*, the acceleration that results is directly proportional to the net force and has a magnitude that is inversely proportional to the mass. The direction of the acceleration is the same as the direction of the net force.

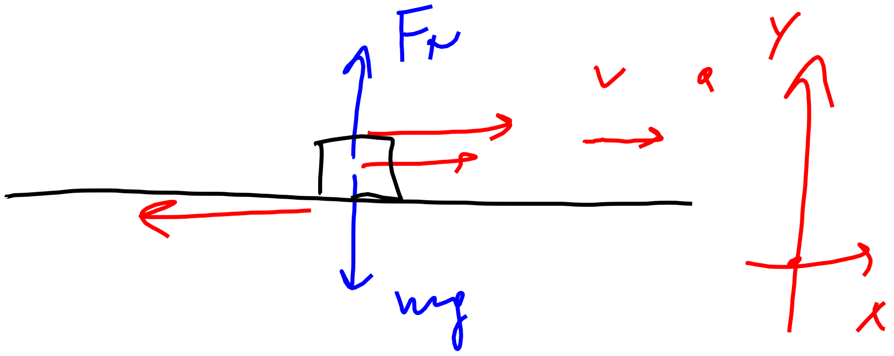


$$\vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m} \Rightarrow \sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

$$N = kg{\cdot}m{\cdot}/s^2$$

Calculate the acceleration of the car.





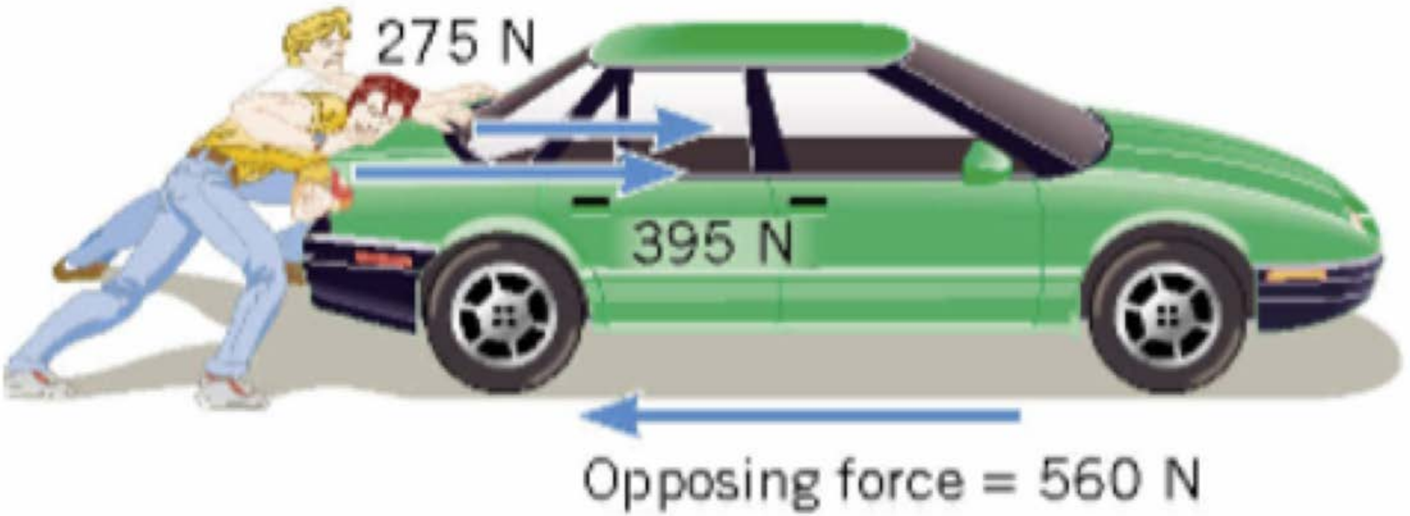
m = 2 T

X: $275 + 395 - 560 = m \cdot a_x = 2000 \cdot a$

$\sum \vec{F} = m \cdot \vec{a}$

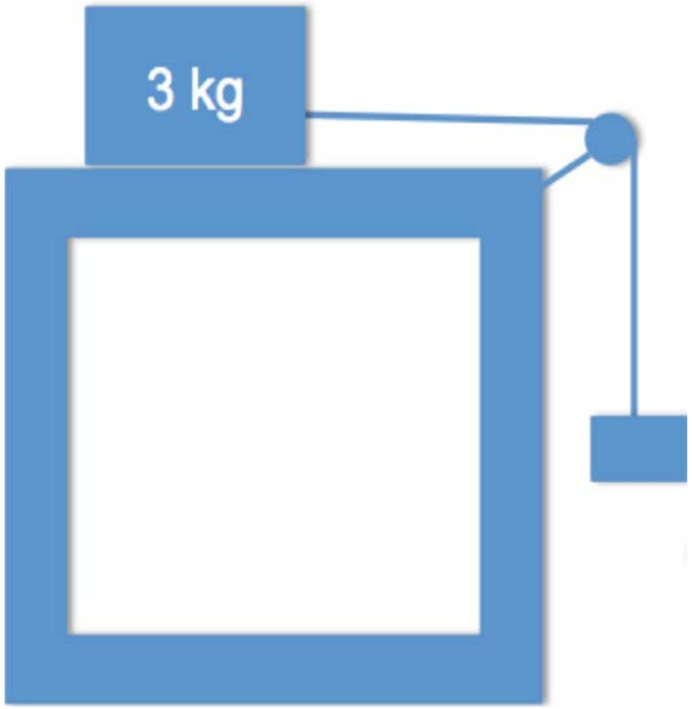
N2L

$m = 2\ T$



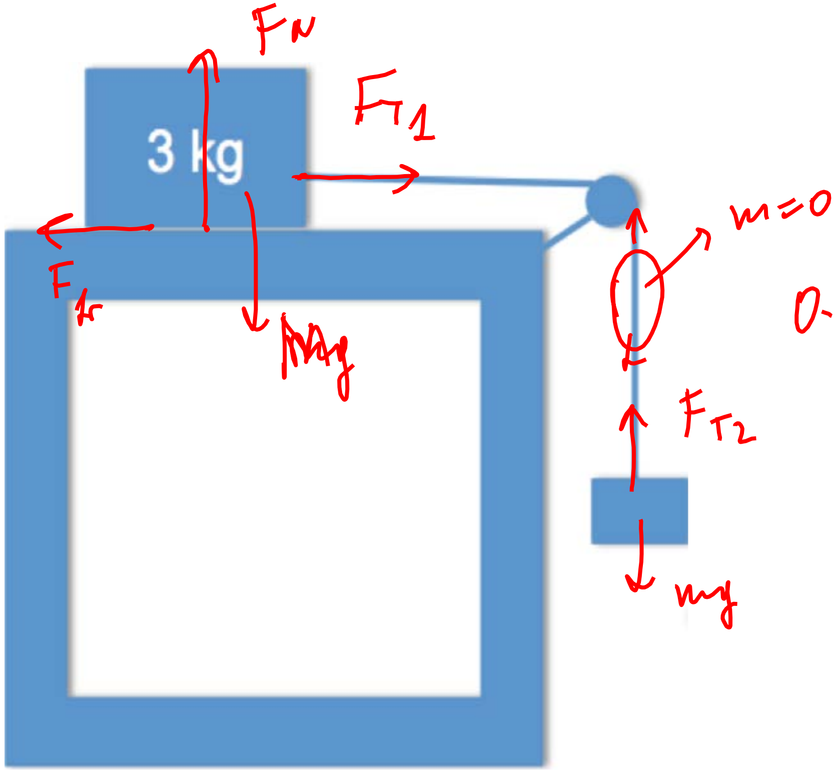
$F_{net} = 110\ N$

$a = 110/2000 \quad = 0.055\ m/s^2$



Draw FBD and write N2L for each weight.

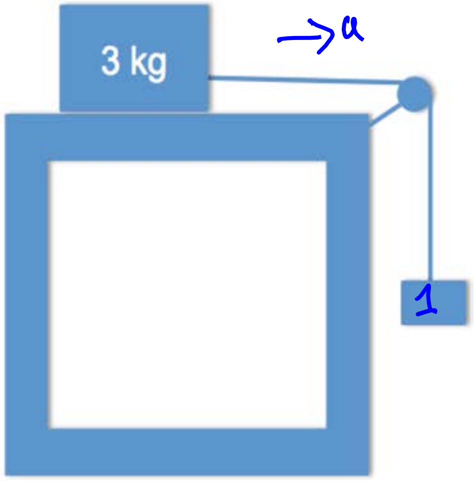
Draw FBD and write N2L for each weight.



$$0 \cdot a = F^* + \hat{F}$$

$$|F_{T1}| = |F_{T2}| = F_T$$

Two blocks are connected by a massless unstretchable string going over the massless frictionless pulley. The big block has the mass 3 times of the mass of the small block; find: (a) the acceleration of the blocks, (b) the tension in the string (use $g = 10\ m/s^2$).



Neglect ANY friction

$3 \cdot 10 = 30\ N$

$F_N = 30$

N2L: $\vec{F}_{Net} = M \cdot \vec{a}$

x: $F_T = 3 \cdot a$

$\vec{F}_{Net} = m \cdot \vec{a}_2$

$F_T - 1 \cdot 10 = 1 \cdot (-a)$

$F_T = 3 \cdot a$

$F_T - 10 = -a$

Physics is done!

The blocks have the same acceleration!

For the big block:

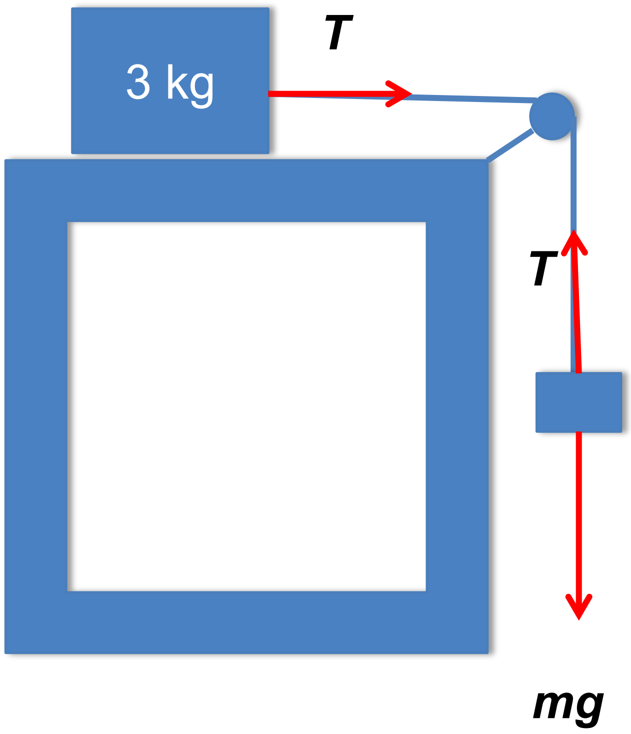
$3*a = T$

For the small block:

$1*10 – T = 1*a$

$\Rightarrow a = 10/4 = 2.5\ m/s^2$

$T = 7.5$ N

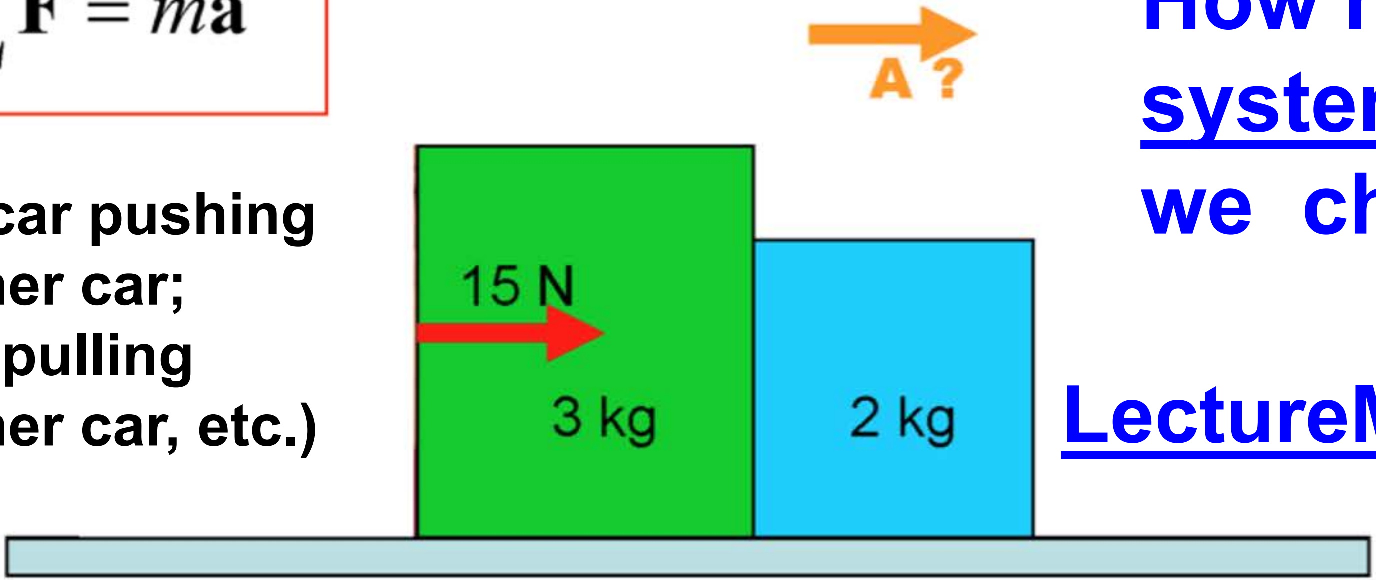


(the picture shows only forces directly related to the acceleration)

Consider a system of two boxes, with a hand exerting a 15 N force to the right on the green box. The green box has a larger mass. Sketch three free-body diagrams (green box, blue box, combined system)

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

(= a car pushing another car; a car pulling another car, etc.)



How many <u>systems</u> *can* we choose?

[LectureMCQ L7 Q4:]()

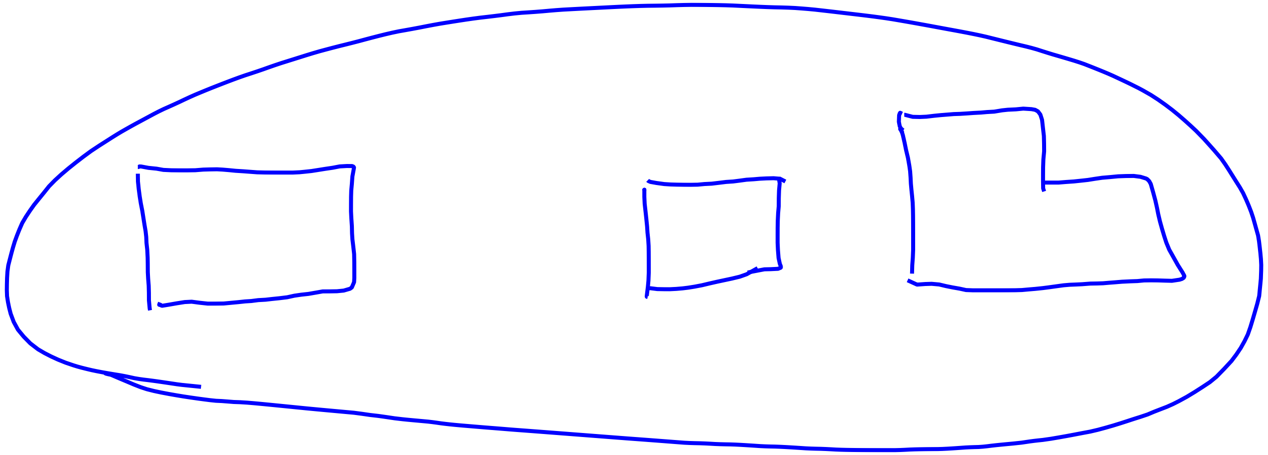
(No friction)

$$\sum \vec{\mathbf{F}} = m\vec{a}$$

LectureMCQ L7 Q4:

How many systems *can* we choose?

That many N2L we can write!



$$\sum \vec{F} = m\vec{a}$$

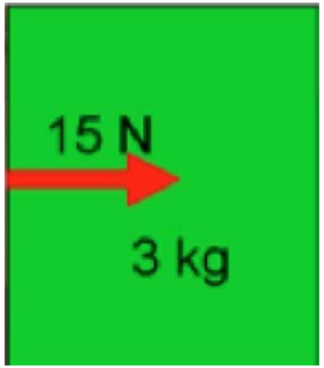
How many systems can we choose?

3

I

II

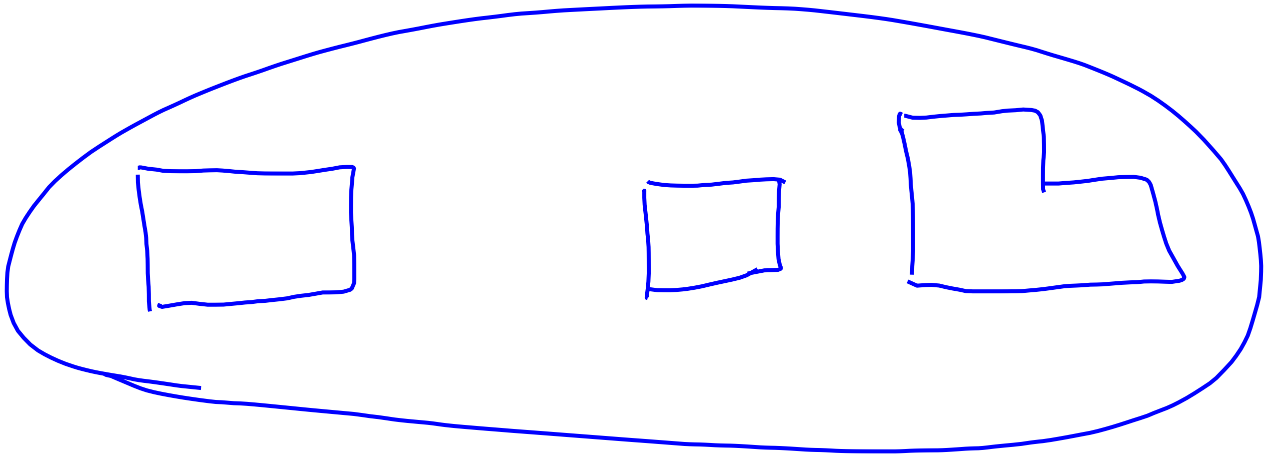
III



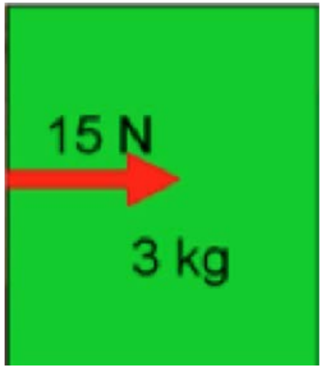
$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

How many systems can we choose?

3



III



$$\sum \vec{F} = m\vec{a}$$

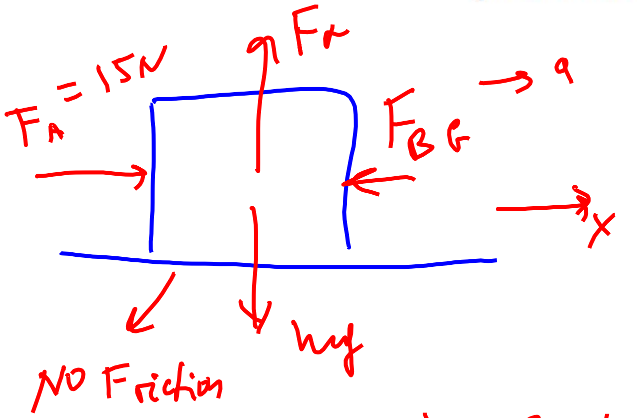
How many N2L can we write?

=> 3

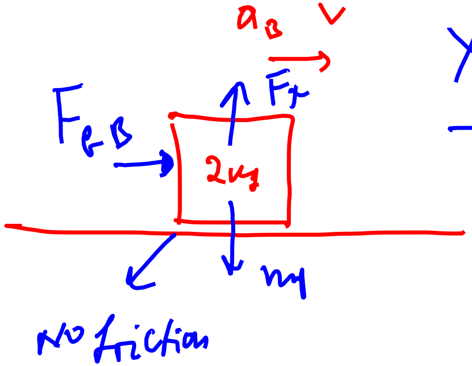
N3L

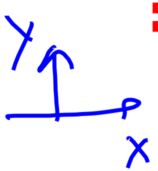
$$|F_{GB}| = |F_{BG}|$$

$$a_G = a_B = a$$

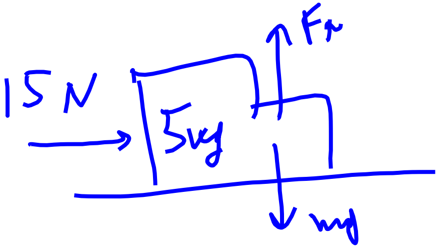


1) $15 + (-F_{BG}) = 3 \cdot a_G$





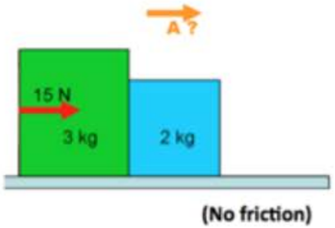
2) $F_{GB} = 2 \cdot a_B$



x: $15 = 5 \cdot a$

$a = \frac{15}{5} = 3\ m/s^2$

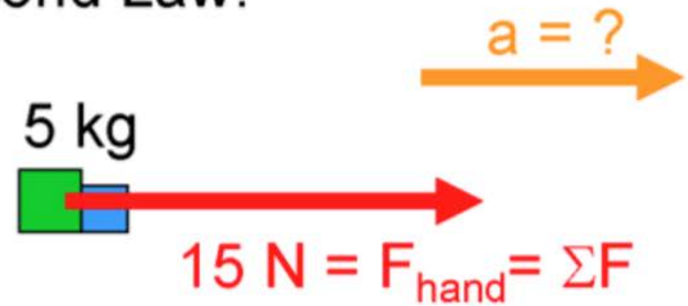
Find the acceleration



Let's choose positive to be to the right.

Which of the three free-body diagrams (for horizontal components) should we use? (Vertical: m**g** just cancels $\mathbf{F}_\mathbf{n}$)

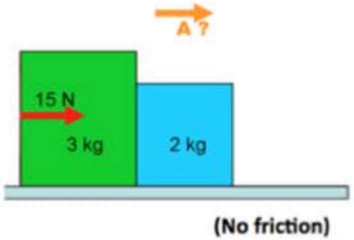
The simplest is the free-body diagram of the two-box system. Apply Newton's Second Law.



$$\sum \vec{F} = (m_g + m_b)\vec{a}$$

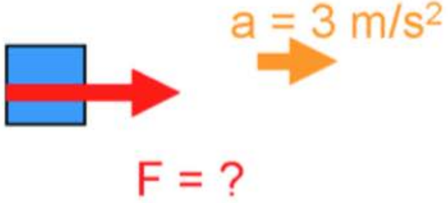
$$\vec{a} = \frac{\sum \vec{F}}{(m_g + m_b)} = \frac{+15\ \text{N}}{5.0\ \text{kg}} = +3.0\ \text{m/s}^2 \rightarrow$$

Find the force the green box applies to the blue box.



Which free-body diagram should we use?

Let's use the free-body diagram of the blue box.

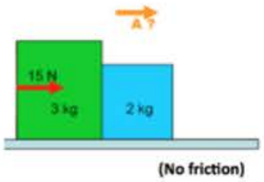


Apply Newton's Second Law.

$$\sum \vec{F} = m_b \, \vec{a} = 2.0 \text{ kg} \times (+3.0 \text{ m/s}^2) = +6.0 \text{ N}$$

The vertical forces cancel one another, so the net force is the force the green box applies to the blue box, 6.0 N to the right.

Find the force the blue box applies to the green box.

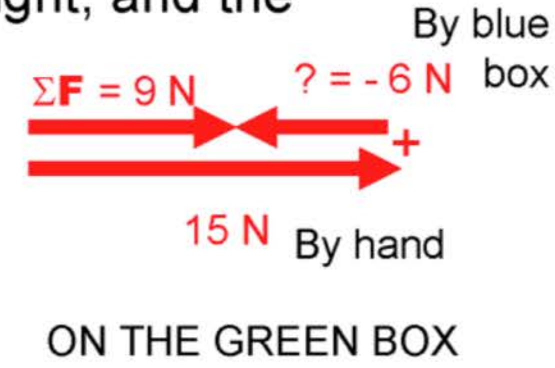


In this case, let's use the free-body diagram of the green box.

Apply Newton's Second Law.

$$\sum \vec{F} = m_g\ \vec{a} = 3.0\ \text{kg} \times (+3.0\ \text{m/s}^2) = +9.0\ \text{N}$$

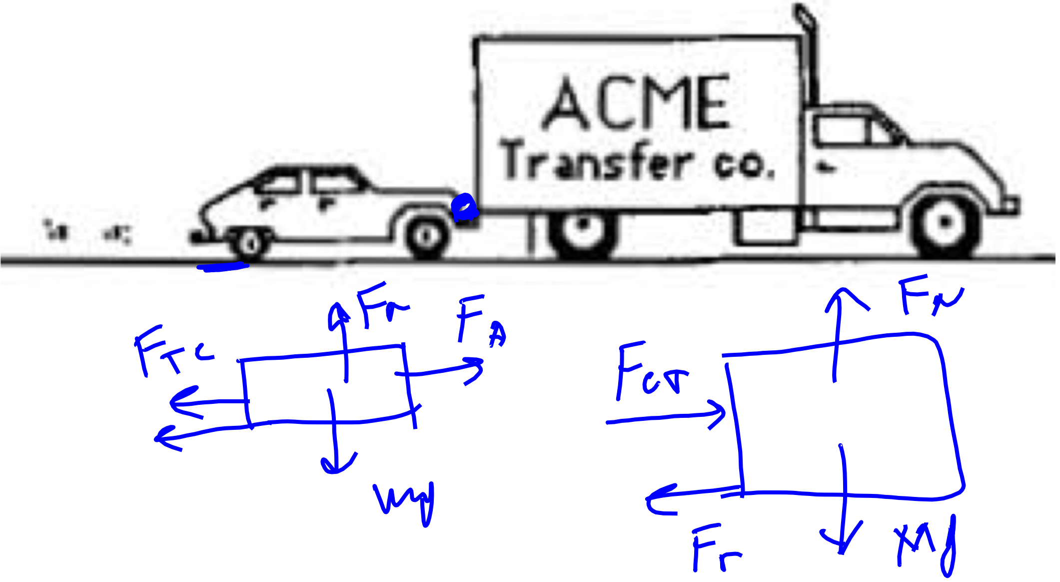
The vertical forces cancel, and the net force is the vector sum of the 15 N force directed right, and the force the blue box exerts to the left.



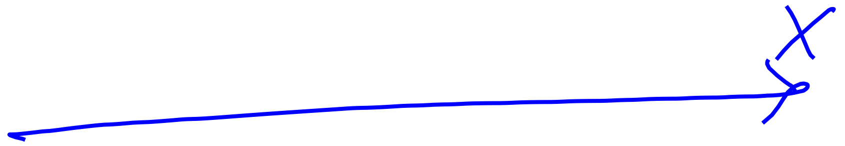
$$+15.0 + \vec{F}_{N,bg} = +9.0\ \text{N}$$

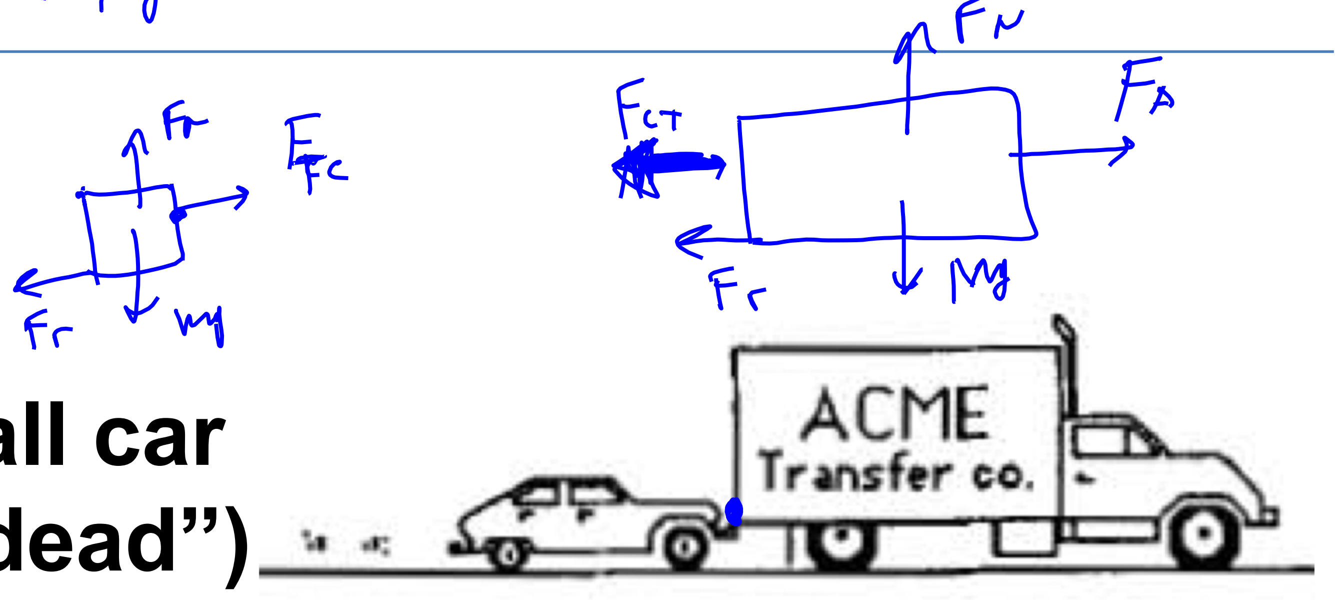
$$\vec{F}_{N,bg} = +9.0\ \text{N} - 15.0\ \text{N} = -6.0\ \text{N}$$

This agrees with Newton's Third Law.

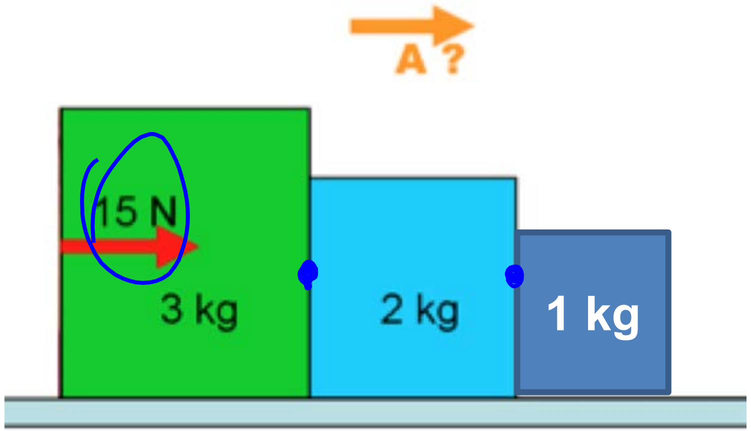


A small car ***pushes*** the big truck (which engine is "dead")





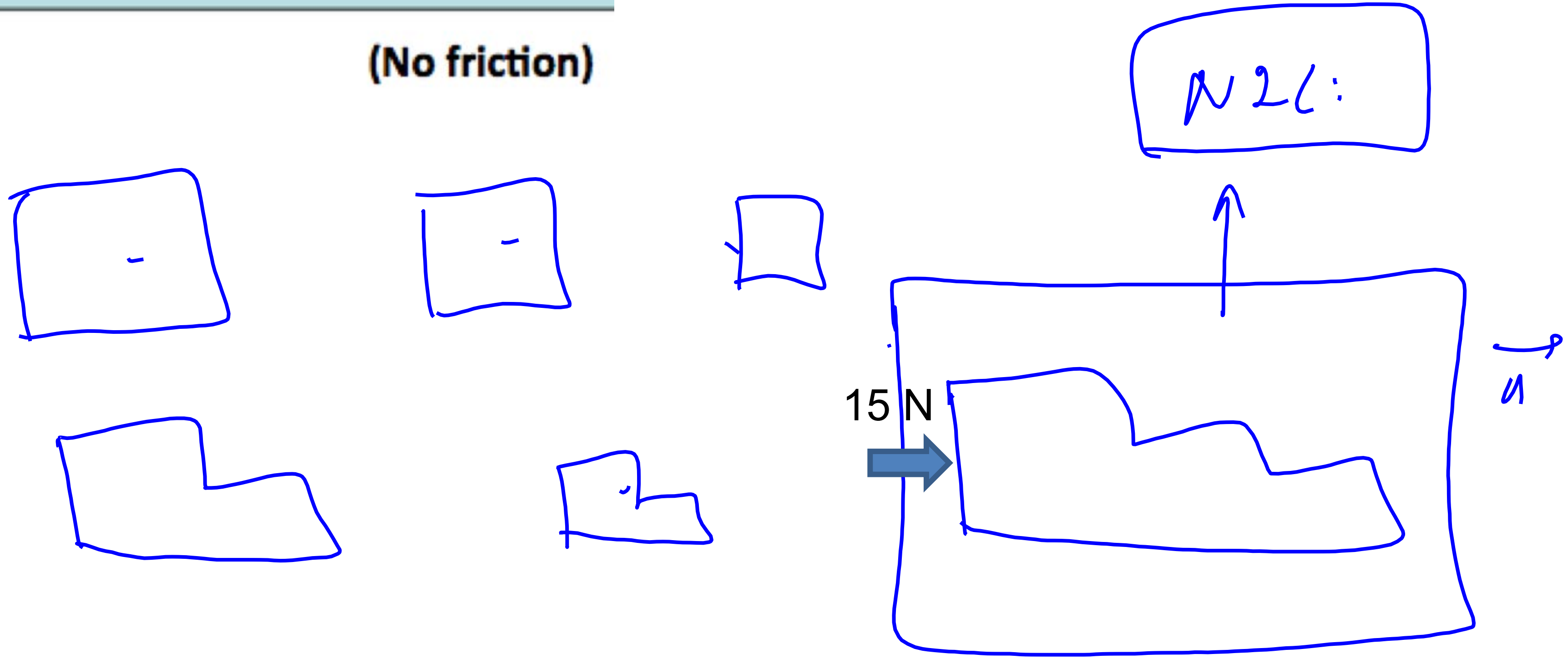
A truck tows a small car (which engine is "dead")



(No friction)

$$\sum \vec{F} = m\vec{a}$$

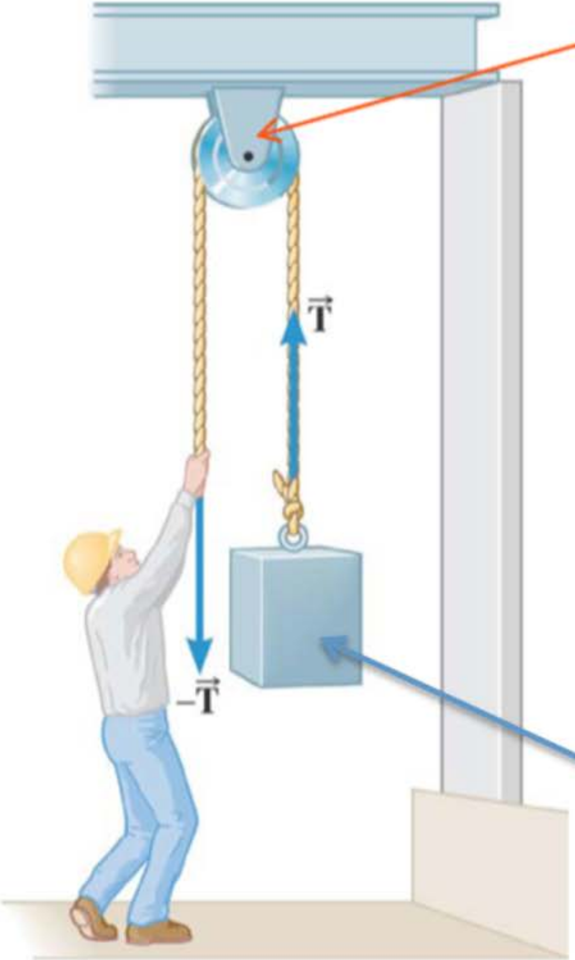
How many <u>systems</u> *can* we choose?



The Tension Force

The guy holds the weight.

Can we find this force?



A massless rope will transmit tension undiminished from one end to the other.

If the rope passes around a massless, frictionless pulley, the tension will be transmitted to the other end of the rope undiminished.

30 kg

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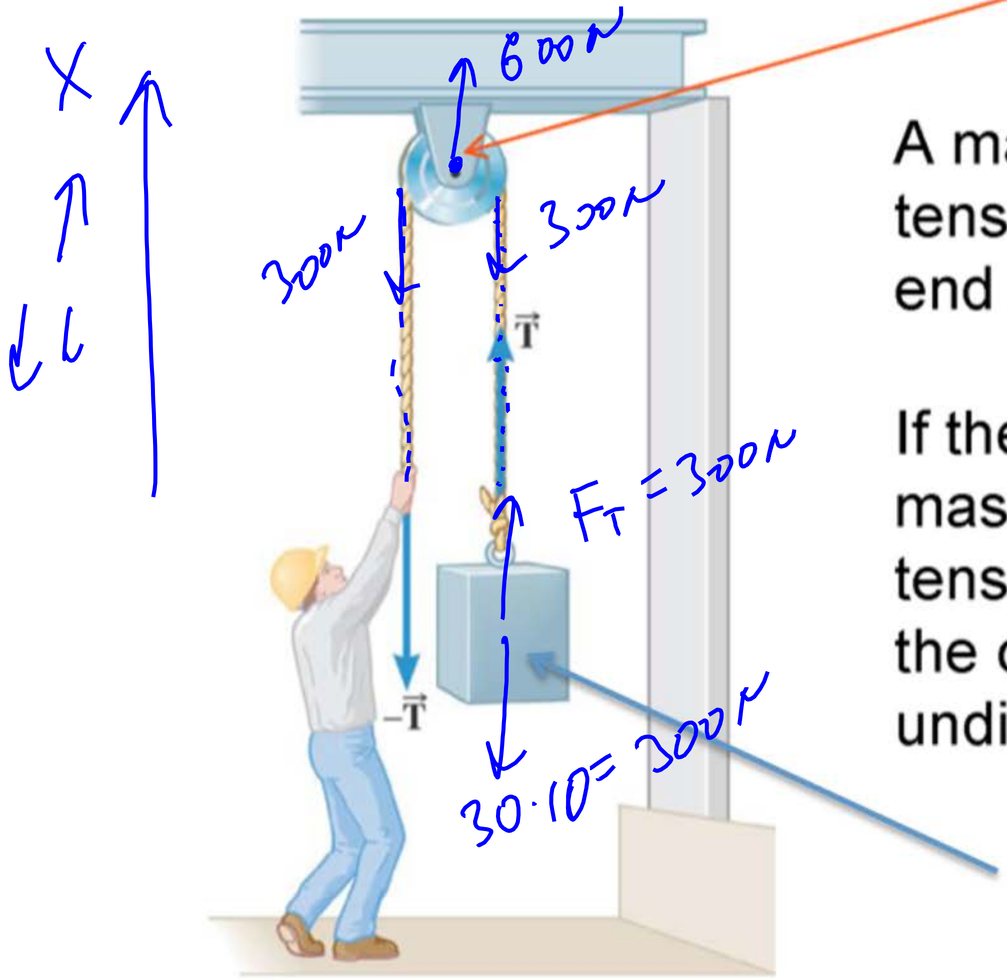
The guy holds the weight.

Can we find this force?



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