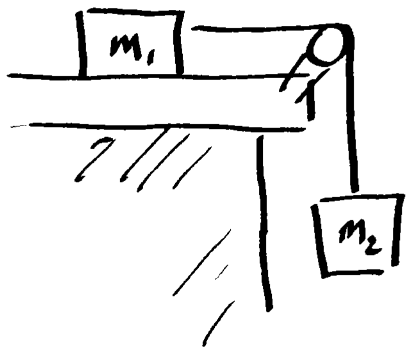
Example

Suppose system is in equilibrium

(No Acceleration, No Motion)



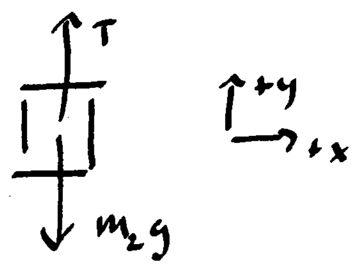
$m_2 = 20$ kg

$m_1 = 10$ kg

What is the smallest μ_s

That can lead to this condition

FBD on Mass 2

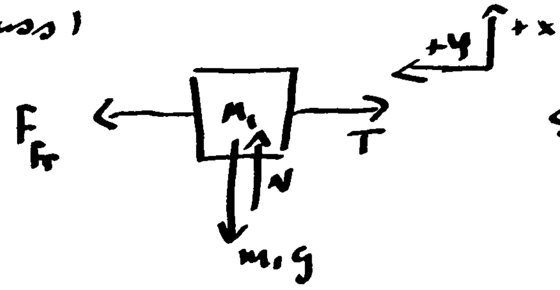


$\sum F_y = m a_y = T - m_2 g = 0$

$\boxed{T = m_2 g}$

$\sum F_x = 0 \quad a_x = 0$

FBD on Mass 1



$\sum F_x = m_1 a_x = 0 = N - m_1 g$

$\boxed{N = m_1 g}$

$\sum F_y = m_1 a_y = T - F_{Fr}$

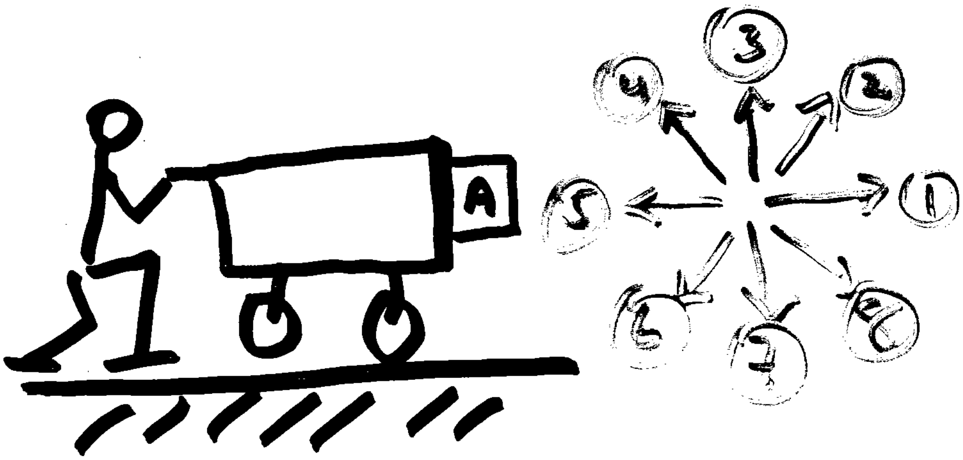
Equilibrium $a_y = 0$

$\therefore \boxed{T = F_{Fr} = \mu_s N}$

$\mu_s = \dfrac{M_2 g}{M_1 g} = \dfrac{M_1}{M_2}$

$\therefore m_2 g = \mu_s N \qquad \boxed{\mu_s = \dfrac{m_2 g}{N} = \cancel{\dfrac{m_2 g}{m_1 g}}}$

Person pushes cart w/ acceleration a



Box A NOT attached.

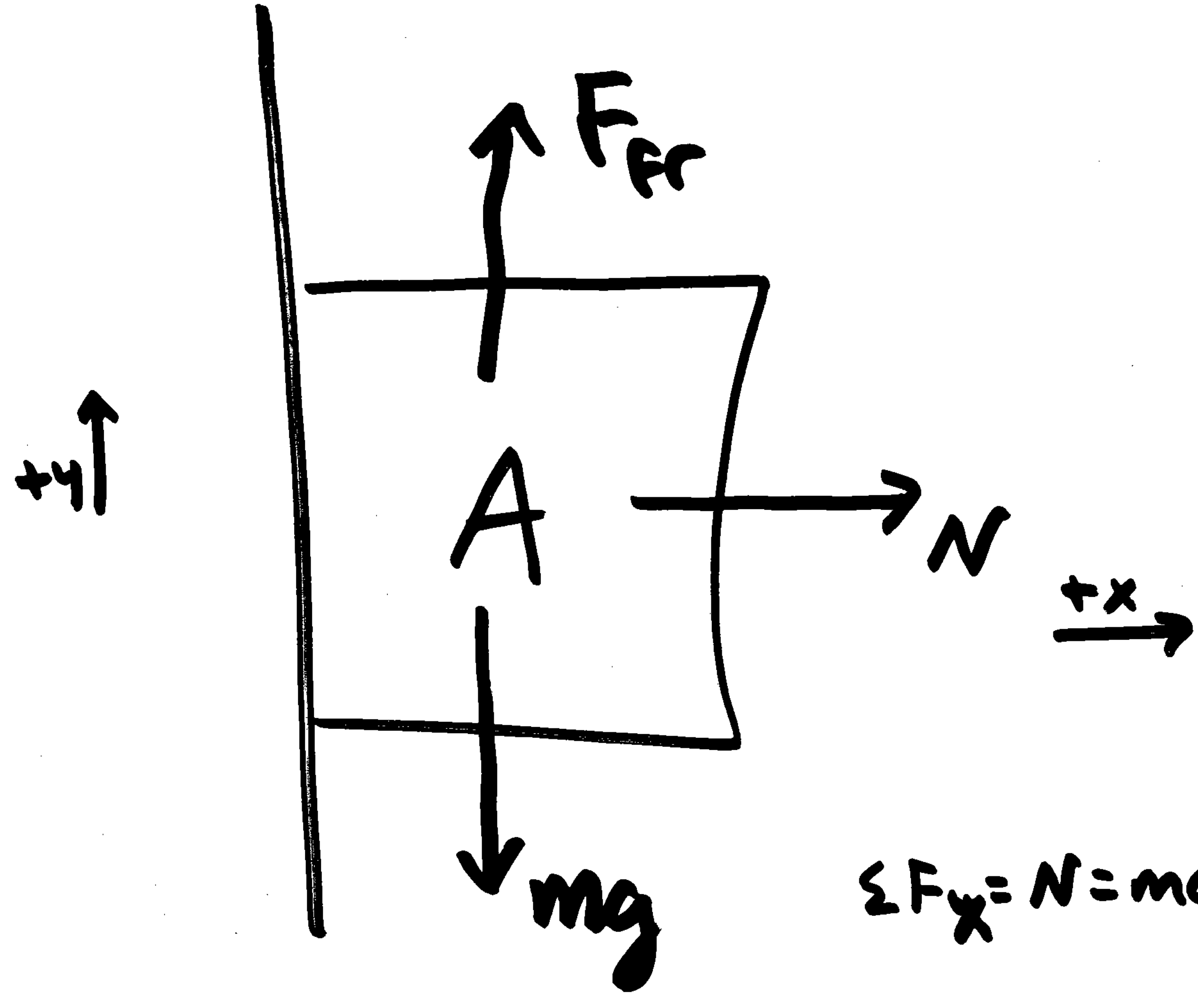
Coeff of friction between box and cart is μ_s.

Force of Friction is in what direction?

Magnitude of F_{fr} is

(Box does NOT slip)

1. 0
2. mg
3. ma
4. $\mu_s mg$
5. $\mu_s ma$



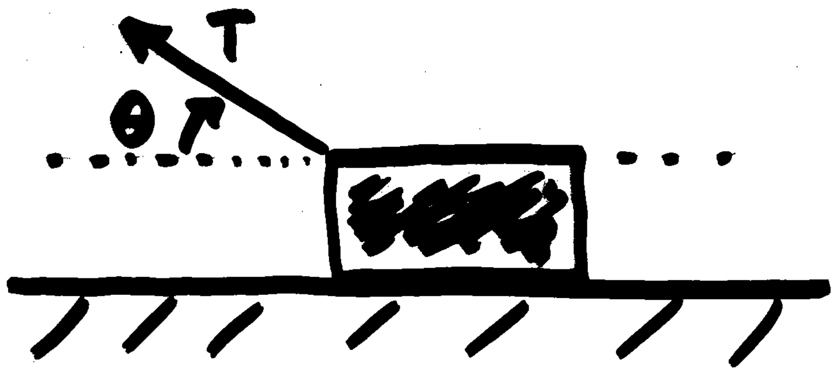
$$\Sigma F_x = N = ma$$

$$\Sigma F_y = 0 = F_{fr} - mg$$

$$F_{fr} = \mu_s N = \mu_s ma$$

Also $= mg$

2 and 5 are correct



Block of mass m pulled as shown across rough surface w/ const Acceleration $\vec{a}$. The magnitude of the frictional force is

① $\mu_K mg$

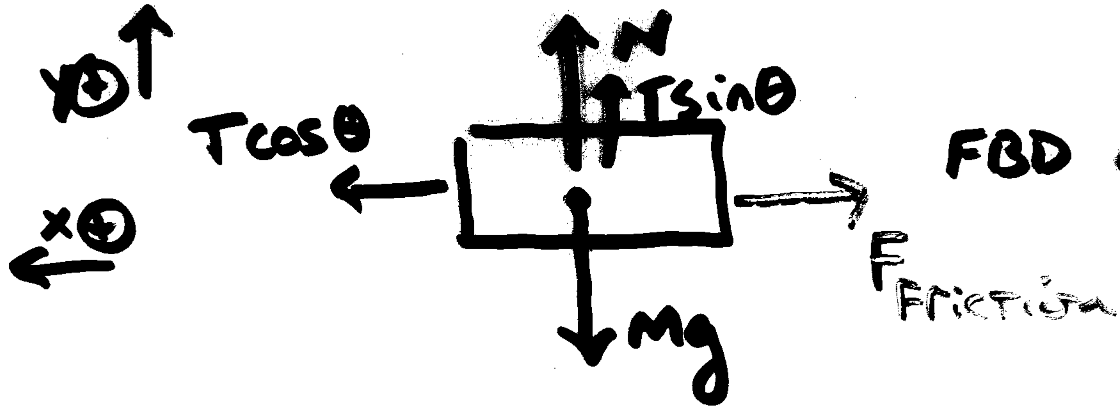
② $T\cos\theta - mg$

③ $T\cos\theta - ma$

④ $\mu_K(T - mg)$

⑤ $\mu_K(T\sin\theta)$

⑥ $\mu_K(mg + \sin\theta)$



FBD of block

[redacted]

$$\Sigma F_y = ma_y = 0 = N + T\sin\theta - mg$$

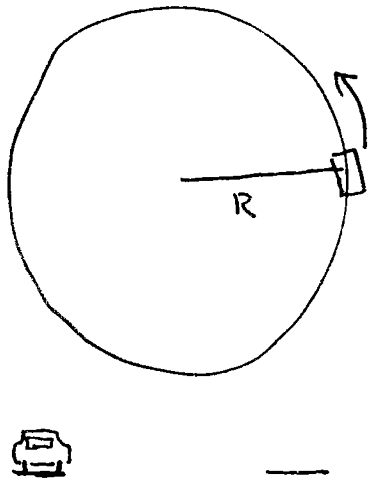
$$\boxed{N = mg - T\sin\theta}$$

$$\Sigma F_x = ma_x = ma = T\cos\theta - F_{friction}$$

$$F_{friction} = T\cos\theta - ma$$ ANS. 3 ✓

$$F_{friction} = \mu_k N = \mu_k (mg - T\sin\theta)$$

Example



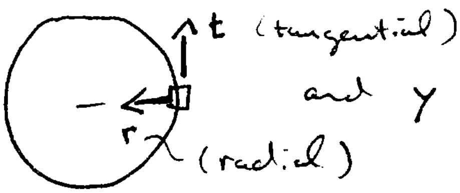
A Car drives in a circle of radius R (50 m)

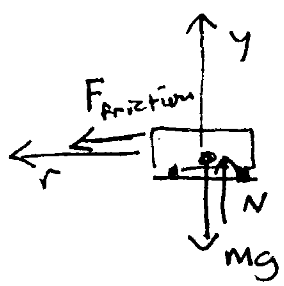
Moves at a speed of 20 km/hr (CONSTANT)

What is the minimum coefficient of ~~kinetic~~ STATIC ~~friction~~ Friction μ_s required to keep the car on the road?

$$20\ \text{km/hr} \times \frac{1000\ \text{m}}{\text{km}} \times \frac{1\ \text{hr}}{3600\ \text{s}} = 5.5\ \text{m/s}$$

Coord choice





$$\sum F_{tangential} = 0 \qquad a_{tangential} = 0$$

$$\sum F_y = 0 = N - mg \quad \Rightarrow \quad N = mg$$

$$\sum F_{radial} = m\frac{v^2}{R} = F_{Fr} = \mu_s N$$

circular Motion

$$m\frac{v^2}{R} = \mu_s mg$$

$$\frac{v^2/g}{R} = \mu_s = 0.06$$

$\frac{m^2/s^2}{m} \Big/ m/s^2$ unit ✓

μ_k large means v can be big or R small.

Work + Energy

What is energy ?

What is Work ?

Push a car for 1 mile … is that work? … yes

(Force)(distance) ~ Work

We'll define more carefully soon

Energy … ~~loosely~~ loosely … Ability to do Work.

Energy is Conserved. That is to say ~~this~~ cannot be ~~neither~~ created OR destroyed !

Ask … can energy be created or destroyed ?

IT can take on Many different forms

Mechanical Energy

Mass energy - $E = mc^2$

heat energy

Kinetic energy - Energy associated w/ Motion

What does potential mean to you

Potential energy - Energy stored in system due to configuration

Work, Energy … different faces of the same thing

Same units $\rightarrow$ MKS Joule

$$\text{Joule} \sim (\text{force})(\text{distance}) = N\,m = kg\frac{m}{s^2}\,m = kg\frac{m^2}{s^2}$$

What does the word "Potential" mean to you.

You have potential.

If nothing else interferes you can do something

Potential to be wealthy

Potential to be a good writer

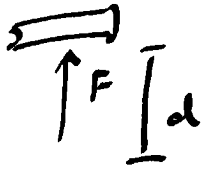
" " do something else

Hey man, she's got potential!

Consider book ... Pick it up

do work against gravity

Physical work vs. Biological work



Suppose I carry it w/out Δ'ing height

Is this work?

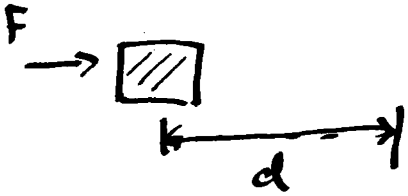
It may seem so ... but in physics we say <u>NO</u>.

You're NOT ~~enhanced~~ changed ability of book to do work

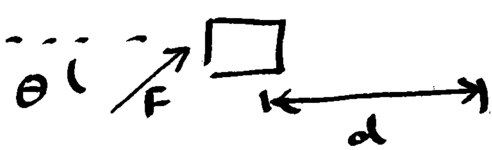
i.e. changed its energy.

whereas you <u>did</u> when you picked it up

Work ≡ The work done by a force on a particle (or object) is equal to the force times the distance through which that particle (or object) is moved along the line of the force

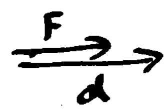


$$\text{work} = Fd$$

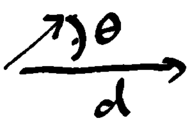


$$\text{work} = F\cos\theta\, d$$

$\vec{d}$ is a vector ... displacement



$$\text{work} = Fd$$



$$\text{work} = F\cos\theta\, d$$

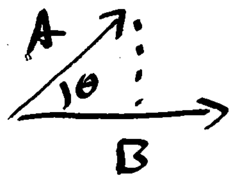
or

$$Fd\cos\theta$$

Work ≡ component of force along direction of movement times the distance moved

-or-

≡ Force times component of distance moved along the direction of force.



2 vectors w/ angle between

$|\vec{A}|_{\text{along } B} = A\cos\theta$

$|\vec{B}|_{\text{along } A} = B\cos\theta$

use this very often ... let's define a vector Dot product

$$\underbrace{\vec{A}\cdot\vec{B}}_{} = |\vec{A}|\,|\vec{B}|\cos\theta$$

gives the (projection of $\vec{A}$ along $\vec{B}$) x ($|\vec{B}|$)

or ($|\vec{A}|$) x (projection of $\vec{B}$ along $\vec{A}$)

Also

$$\vec{A}\cdot\vec{B} \overset{\cancel{\text{also}}}{=} A_x B_x + A_y B_y + A_z B_z$$

NOTE these are scalars, NOT vectors

Dot product also called Scalar product

Proved on p 19/20 of text

$\vec{A}\cdot\vec{A} = ?$

$= |\vec{A}|\,|\vec{A}|\cos\theta = |\vec{A}|\,|\vec{A}|$

$$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos 90 = 0$$

No projection possible here!

Example

$$\vec{A} = 3\hat{i} + 4\hat{j} + 2\hat{k}$$

$$\vec{B} = 1\hat{i} + 0\hat{j} + 9\hat{k}$$

Ask for Arbitrary (bet 0 + 10) components from class

$$\vec{A} \cdot \vec{B} = (3)(1) + (4)(0) + (2)(9) = 4 + 18 = 22$$

What is opening angle between $\vec{A}$ and $\vec{B}$?

$$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos\theta$$

$$|\vec{A}| = \sqrt{3^2 + 4^2 + 2^2} = \sqrt{29}$$

$$|\vec{B}| = \sqrt{82}$$

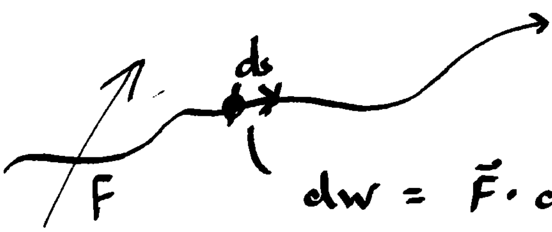
$\cancel{22 = \sqrt{82}}$

$$22 = \sqrt{29}\sqrt{82} \cos\theta$$

Solve for θ $\qquad \theta \sim 63^\circ$

Since Work uses the projected component of Force along distance $\Rightarrow$ conveniently defined in terms of vector scalar or dot product

$$W \equiv \vec{F} \cdot \vec{S} \quad \text{for constant vectors}$$



$$dw = \vec{F} \cdot d\vec{s}$$

$$W = \int \vec{F} \cdot d\vec{s} \quad \text{for varying } \sout{\text{force}} \text{ force / path}$$

$$W = \int (F_x dx + F_y dy + F_z dz)$$