No Labs today

Note: exam room change:
Exams 2,3 take place in STO B50

1. Please pick up your exam (but only yours!!)
The grades and the solution are on BB.

Good morning!

2. Please, login into webassing, locate LectureMCQ_L9 (PY105) and answer question 1 (but ONLY Q1!)

LectureMCQ_L9 Question 2 !

Please, asses your expectation regarding the exam

1. The Exam was much harder than I expected
2. The Exam was somewhat harder than I expected
3. The Exam was about as I expected
4. The Exam was somewhat easier than I expected
5. The Exam was much easier than I expected
6. The Exam was way too short.
7. I am still in the fog, cannot remember anything what happened yesterday
8. I took PY211 exam by mistake, it was OK

LectureMCQ_L9 Question 2 !

1 The Exam was much harder than I expected

6.10% 5

2 The Exam was somewhat harder than I expected

25.6% 21

3 The Exam was about as I expected

45.1% 37

4 The Exam was somewhat easier than I expected

17.1% 14

5 The Exam was much easier than I expected

3.66% 3

6 The Exam was way too short.

7 I am still in the fog, cannot remember anything what happened yesterday

2.44% 2

Exam1

40	39	38.3	36	33.3
40	39	38.3	36	32.8
40	39	38	35.8	32.8
39.8	39	38	35.5	32.5
39.8	39	37.8	35.5	32.3
39.8	38.8	37.8	35.5	32
39.5	38.8	37.5	35.5	30.5
39.5	38.8	37.5	34.8	30
39.5	38.5	37.5	34.8	30
39.5	38.5	37.5	34.5	29.8
39.5	38.5	37.5	34.5	29
39.3	38.5	37.3	34.3	28.8
39.3	38.5	37	34	27.8
39.3	38.5	36.5	34	27.8
39.3	38.5	36.3	33.8	26.3
39	38.5	36.3	33.3	23.8
39	38.3	36	33.3	23.5

22.8
22.5
19.5

Average: 35.4773 out of 40

Out of 100 %

90 - 100	53
80 - 89	21
70 - 79	6
60 - 69	3
50 - 59	4
40 - 49	1

Average: 88.69 out of 100

Slides
Enabled: Statistics Tracking

Textbook

some old exams
Enabled: Adaptive Release

Equation sheets
Enabled: Statistics Tracking

IL (labs)
Enabled: Adaptive Release, Statistics T

Old Slides (2017)
Enabled: Adaptive Release, Statistics T

EchoCenter

??????

PRACTICING the use of the list of actions

TRYING TO ENACTING THE ACTIONS

THE MEANING SENTENCES =
LIST OF ACTIONS

SENTENCES

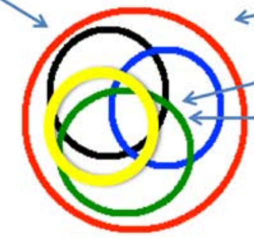
WORDS

LECTURE

Evolution of understanding

Exam problems — similar → Problems:
1. HW
2. Lectures
3. Units (IL)

Train yourself
in recognition!



Practice HW
Practice exams

Some helpful questions for solving physics problems (page # 12)

1. What objects are involved? What processes are happening to them? (use your imagination - make a picture showing the objects and the processes they are involved into)
2. What properties of the objects and the processes might be important?
3. What physical quantities should be used for describing those properties, what connections might be important?
5. What laws or definitions should be used to describe important connections mathematically?
6. How can I solve my equations mathematically?
8. Does it make a sense?
9. Could I solve a similar problem again? How much time would it take? Who could help me (if I need it)?

http://teachology.xyz/general_algorithm.htm

Practice makes results

Practice problems

Practice exams

Next topics (do not read this slide)

Friction, kinetic energy, work, work-force connection, force-position graph, power, power-force connection, work-kinetic energy theorem, conservative force, potential energy, gravitational potential energy, mechanical energy, non-conservative force, law of conservation of energy, impulse of a force, linear momentum, force-tine graph, closed (isolated) system, law of conservation of linear momentum, a collision, elasticity, four types of collisions, methods for solving collision problems, center of mass (COM), calculating COM, Circular motion (CM), circumference, radius, uniform circular motion (UCM), period, frequency, centripetal acceleration, properties of horizontal UCM, properties of vertical UCM, properties of vertical CM.

HW2P1 recommended deadline = 6/8

actual deadline = 6/17 11 pm

HW2P2 recommended deadline = 6/10

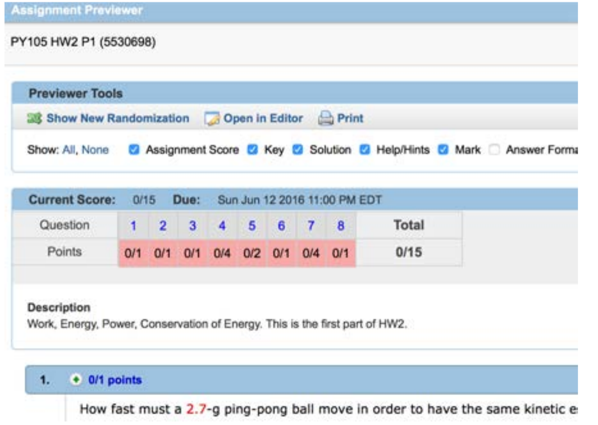
actual deadline = 6/17 11 pm

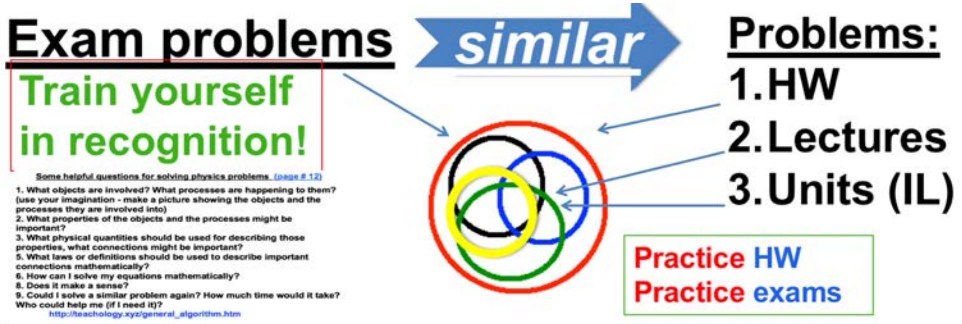
HW2P3 recommended deadline = 6/12

actual deadline = 6/17 11 pm

HW2P4 recommended deadline = 6/15

actual deadline = 6/17 11 pm



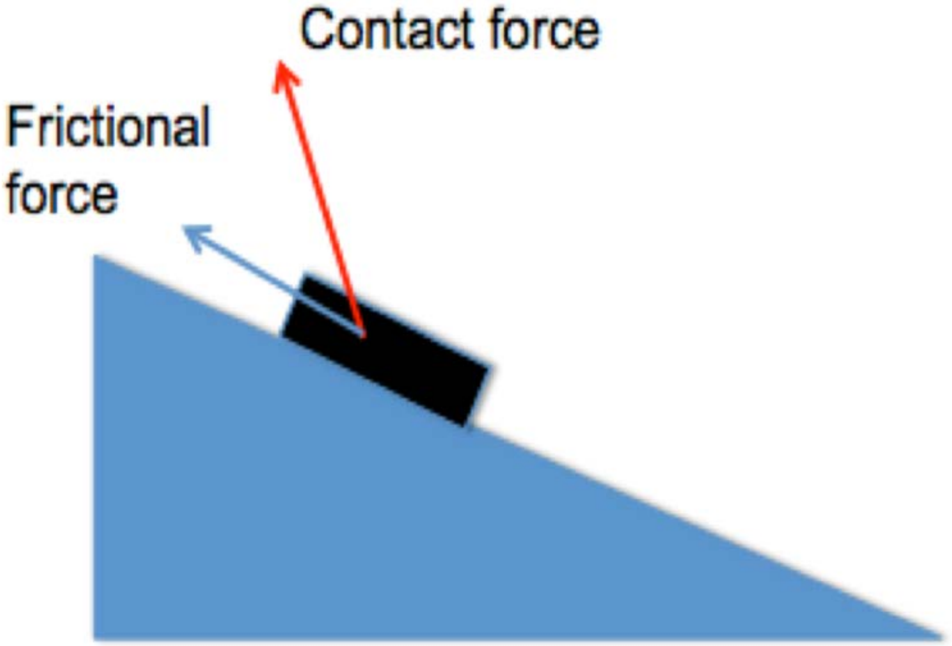


FRICTION!

Force of friction is equal to the component of the contact force which is parallel to the surface.

<u>Static</u> friction: prevents objects from moving

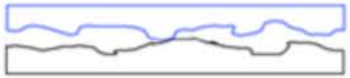
<u>Kinetic</u> friction: opposes the motion



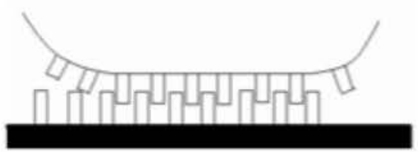
Static and Kinetic Frictional Forces

When the two surfaces are not sliding across one another the friction is called ***static friction***.

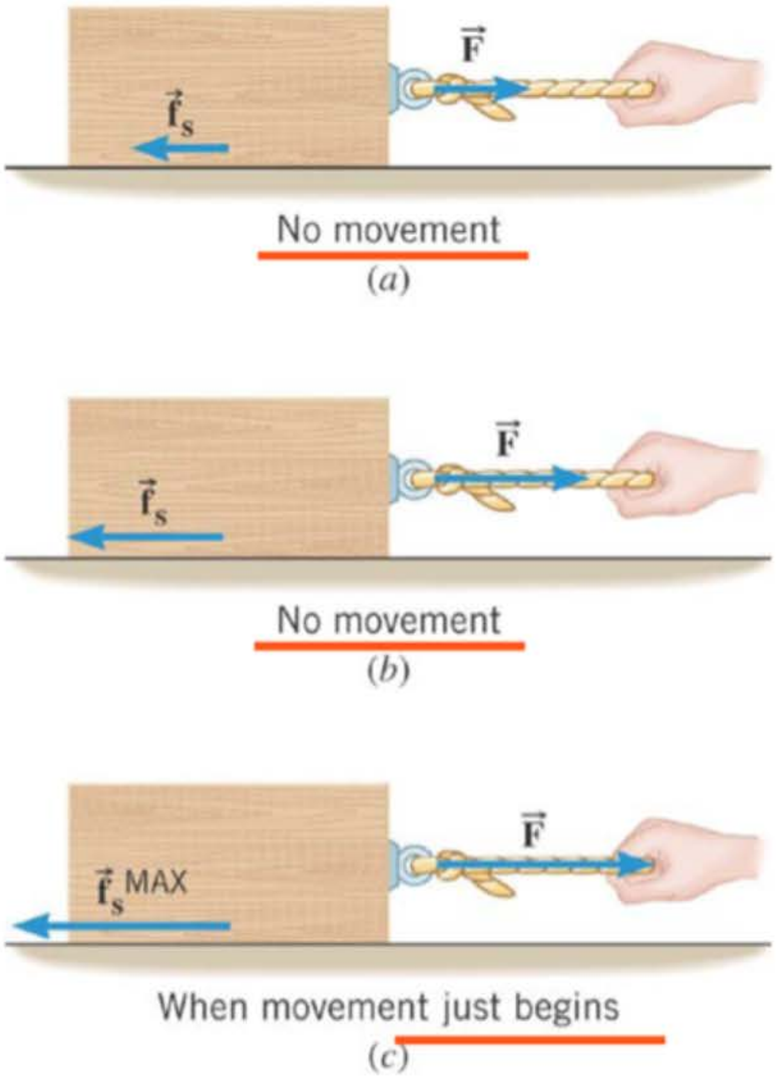
Static friction is the reason we can walk and cars can move!



Static friction between two surfaces works in a similar way with two gears attached to each other.



Viewed under a microscope, a surface generally looks rough. Surfaces put together make contact at very few places. When trying to move past each other, the high parts on each surface get stuck on one another.



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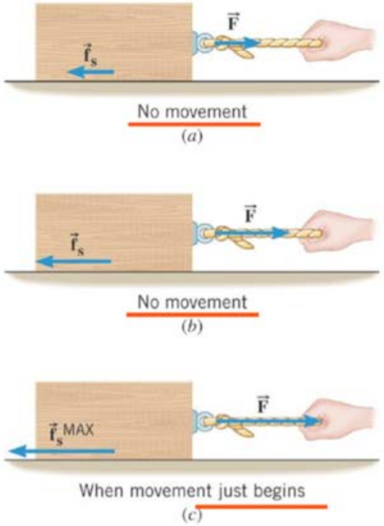

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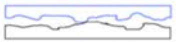


Static friction between two surfaces works in a similar way with two gears attached to each other.

Viewed under a microscope, a surface generally looks rough. Surfaces put together make contact at very few places. When trying to move past each other, the high parts on each surface get stuck on one another.

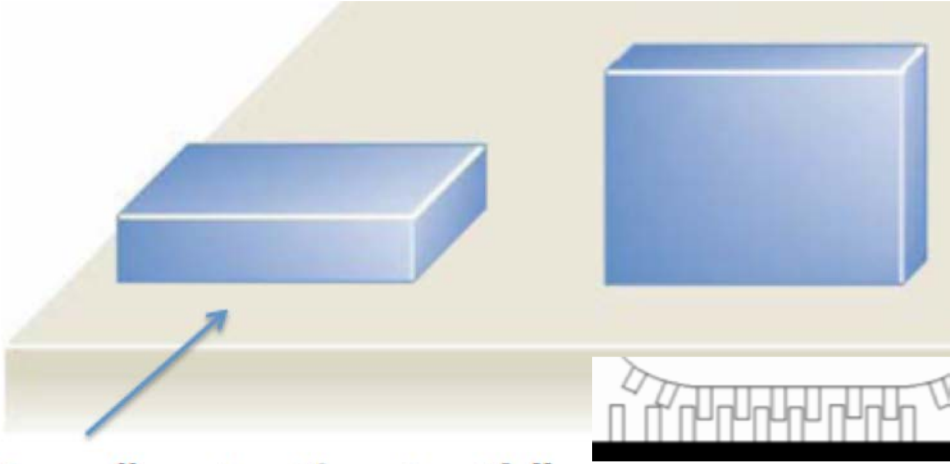
Force of static friction may have ANY magnitude between 0 and its <u>maximum</u> value.

Coefficient of static friction

$$\mu_{st} = \frac{F_{max\_st\_fr}}{F_N}$$

Kinetic friction opposes the relative sliding motion motions that actually does occur.

$$F_{fr} = f_k = \mu_k F_N$$



$$\mu_k = \frac{F_{k\_fr}}{F_N}$$

is called the coefficient of kinetic friction.

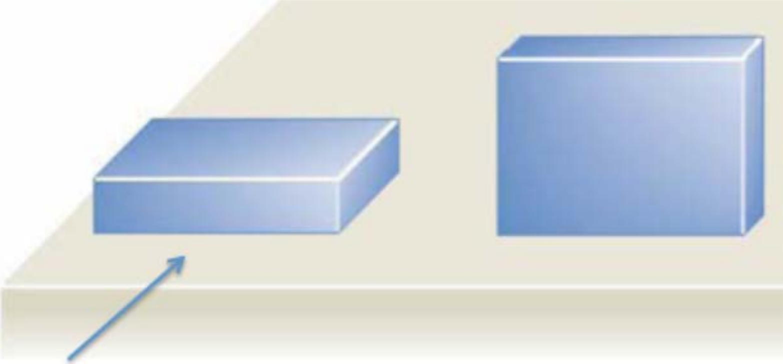
Webassign: L9 Q3

The *unit* of μ is …

1. N 2. kg 3. s 4. moo 5. none

Kinetic friction opposes the relative sliding motion motions that actually does occur.

$$F_{fr} = f_k = \mu_k F_N$$



More "contacting teeth" but less deep into each other.

$$\mu_k = \frac{F_{k\_fr}}{F_N}$$

$$[\mu] = \frac{[F]}{[F]} = \frac{\cancel{N}}{\cancel{N}} = 1$$

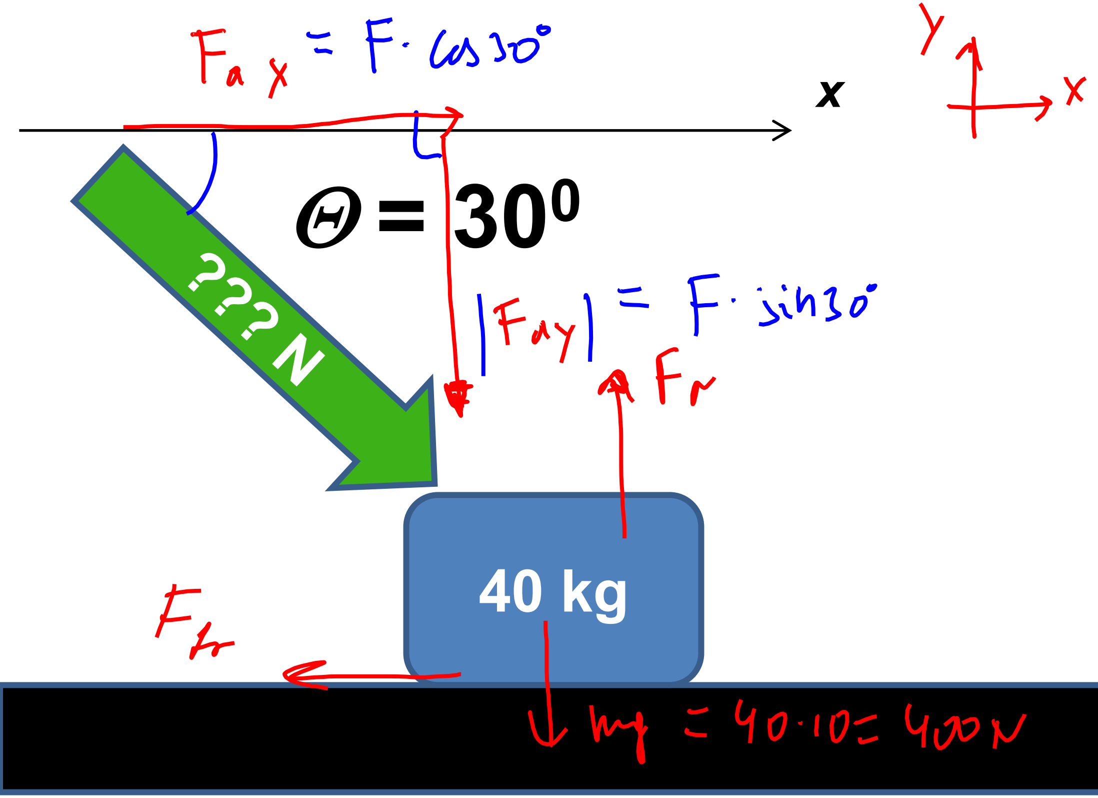
is called the coefficient of kinetic friction.

The unit of μ is …

~~**1. N 2. kg 3. s 4. moo**~~ **5. none**

Find the <u>minimum</u> force which brings the box into a motion, if $\mu_{st} = 0.8$

$$\mu_{st} = \frac{F_{max\_st\_fr}}{F_N}$$



x: $F_{ax} = F_{fr\,max}$

y: $F_N - F_{ay} - 400 = 0$ | N2L

$F_{max\ fr} = \mu_{st} \cdot F_N$

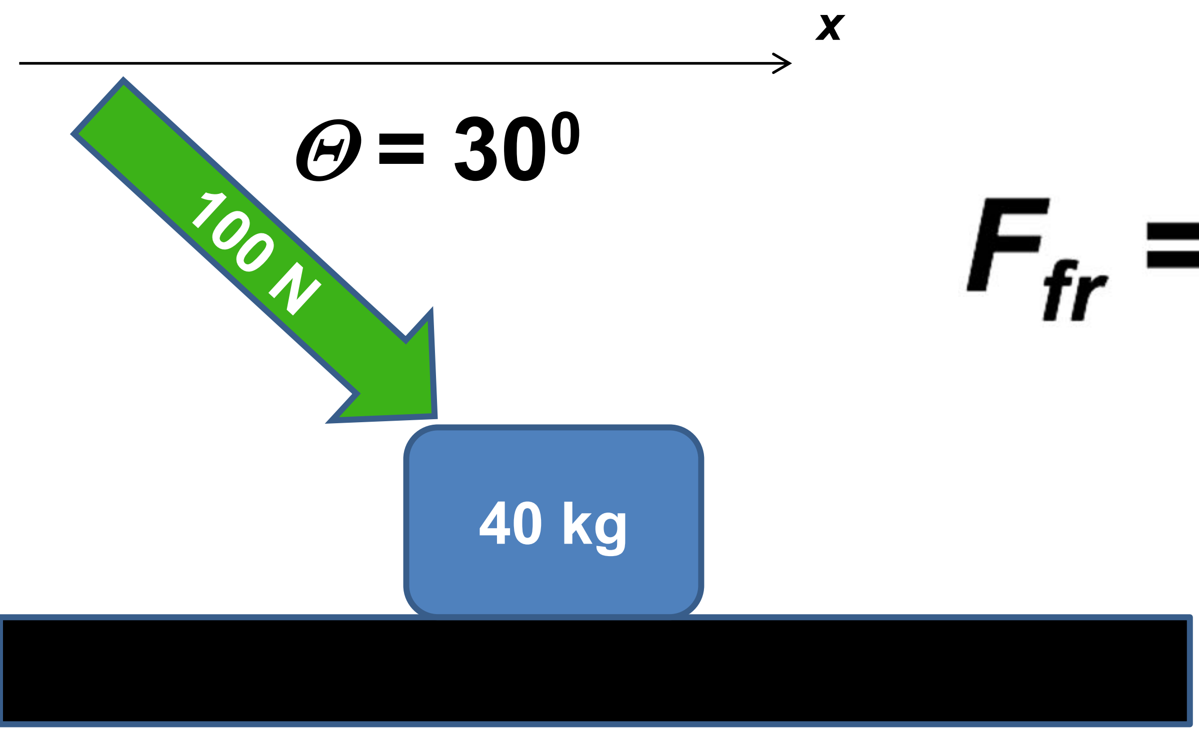
Physics is done:

$F_{ax} = \mu_{st} \cdot (F_{ay} + 400)$

$F \cdot \cos 30^\circ = 0.8 \cdot (F \cdot \sin 30 + 400)$

Math is almost done

Find, what should the value of the coefficient of kinetic friction be equal to in order to push the box at ***constant*** velocity?

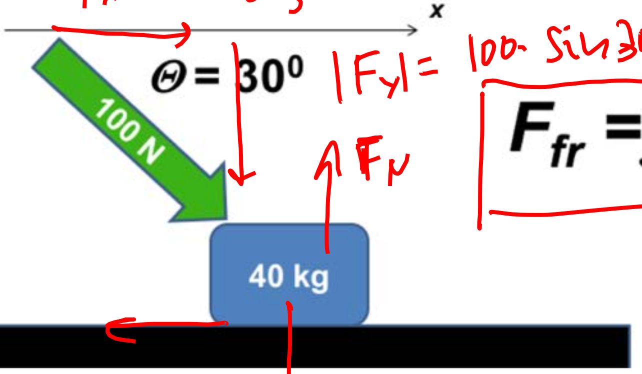


$$\mathbf{F_{fr}} = f_k = \mu_k F_N$$

Find, what should the value of the coefficient of kinetic friction be equal to in order to push the box at *constant* velocity?

$\vec{a} = 0$ $\qquad$ $\vec{v} = \text{const}$

$F_x = 100 \cdot \cos 30$



$|F_y| = 100 \cdot \sin 30^\circ$

F_N

F_{fr} $\qquad$ $mg = 400\ N$

$$\boxed{\mathbf{F_{fr}} = f_k = \mu_k F_N}$$

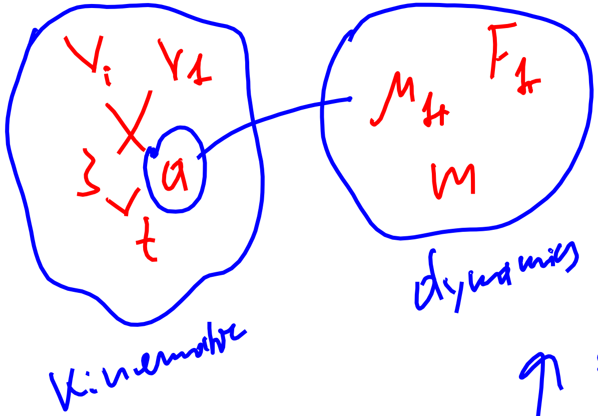
X: $|F_x| = |F_{fr}|$ $\qquad$ Y: $F_N = |F_y| + 400$

$$100 \cdot \cos 30 = \mu_k \left(100 \cdot \sin 30 + 400\right)$$

$$\mu_k = \frac{100 \cdot \cos 30}{100 \cdot \sin 30 + 400}$$

You pushed the box. The initial speed of the box *right after the push* was 15 m/s. If the coefficient of kinetic friction is 0.4, find the distance traveled by the box before it stops.

You push<u>ed</u> the box. The initial speed of the box *right after the push* was 15 m/s. If the coefficient of kinetic friction is 0.4, find the distance traveled by the box before it stops.



$V_f = V_i + a \cdot t$

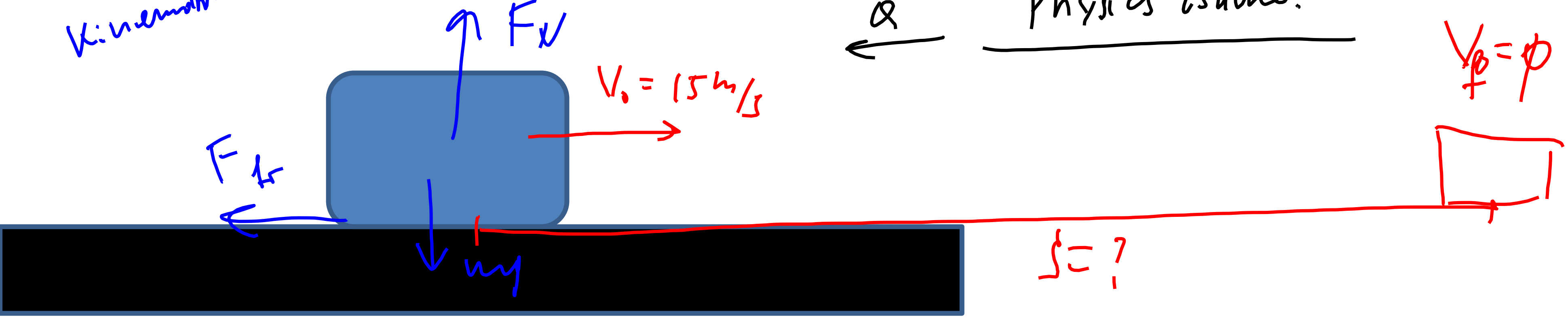
$X = X_i + V_i \cdot t + \frac{1}{2} a t^2$

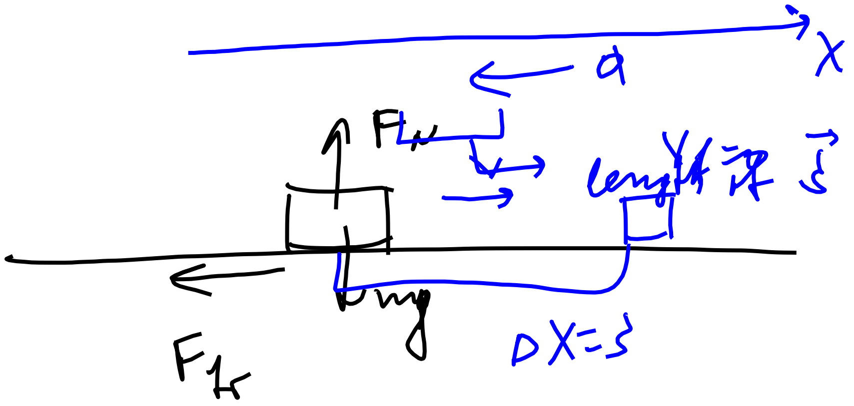
$V_f^2 = V_i^2 + 2 \cdot a \cdot \Delta X$

Y: $F_N = mg = m \cdot 10$

X: $-|F_{fr}| = m \cdot (-a)$

Physics is done!





$$F_N = m \cdot 10$$

$$F_{fr} = m \cdot a$$

$$F_{fr} = \mu_{fr} \cdot F_N$$

$$\mu_{fr} = 0.4$$

$$\cancel{m} \cdot a = \underbrace{F_{fr} = \mu_{fr} \cdot F_N} = \mu_{fr} \cdot \cancel{m} \cdot 10$$

$$v_{f_x}^2 = v_{i_x}^2 + 2 \cdot a_x \cdot s_x$$

$$\boxed{0 = 15^2 + 2 \cdot (-4) \cdot s} \; ; \; s = \frac{15^2}{2 \cdot 4}$$

ENERGY

WORK

Linear momentum

Some Forms of Energy

Kinetic E: $$KE = \frac{mv^2}{2}$$

Gravitational potential E: $$GPE = mgy \quad (y - axis\ is\ UP)$$

Work done by a <u>*const*</u> *F* $$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

The same unit! ➡ J = kg m^2 /s^2 **1 calorie = 4.18400 joules**

Power

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

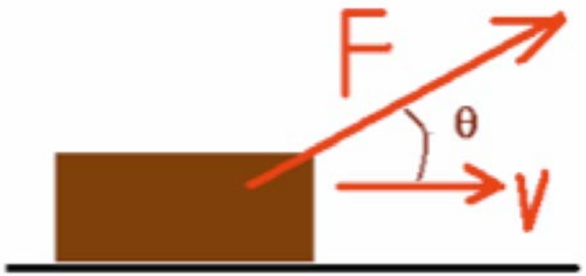
Power is the rate at which work is done.
Power shows how fast the work is done (how fast the energy is changing).
The SI unit for power is the watt (W).

(Note: 1 W = 1 *J/s* 1 hp = 746 W)

$$\boxed{P_{Ave} = \frac{\Delta W}{\Delta t}}$$

$$P = |\vec{F}| * |\vec{v}| * \cos\theta$$

θ is the angle between the force (which is doing the work) and the velocity of the object.



$$\boxed{KE = \frac{mv^2}{2} \geq 0}$$

Gravitational potential E:

$$GPE = mgy \quad (y - axis\ is\ UP)$$

y

Must direct Y- axis UP

Webassign: L9 Q4

Where can we chose the origin?

1. **Above the ground**
2. **At the initial location**
3. **Anywhere**
4. **At the center**

Gravitational potential E: $$GPE = mgy \quad (y-axis\ is\ UP)$$

y

1.Must direct Y- axis UP

2. *GPE* depends on our choice of ZERO level! We can chose it <u>anywhere</u>!

KE is always positive (or 0)

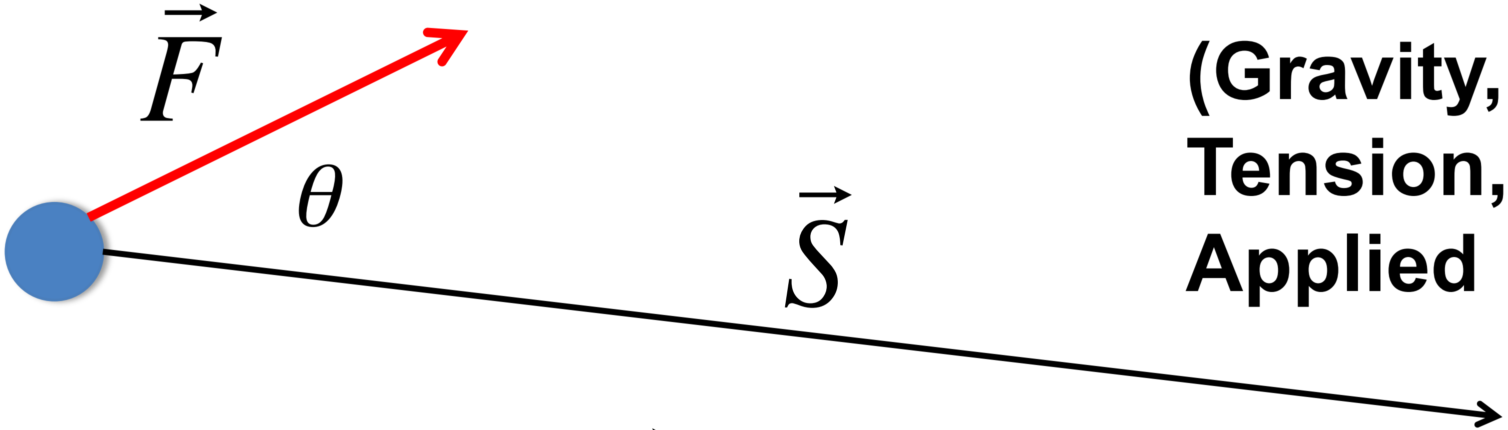
Kinetic E: $$KE = \frac{mv^2}{2} \geq 0$$

y

Gravitational potential E: $$GPE = mgy \quad (y - axis\ is\ UP)$$

Is GPE *always* positive? 1. ~~Yes~~ 2. No

Work done by ***<u>ANY</u>*** ***<u>constant</u>*** **force**



(Gravity, Tension, Applied Force)

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta \Rightarrow J = kg\ m^2/s^2$$

Magnitude of the force

Magnitude of the displacement

An actual angle between the force and the displacement

Work done by a *normal* force

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

Webassign: L9 Q5

You push a box applying a force (as shown in the picture).

The work done by the *normal* force is …

1. < 0
2. = 0
3. > 0

Work done by a *normal* force

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

valbu@bu.edu

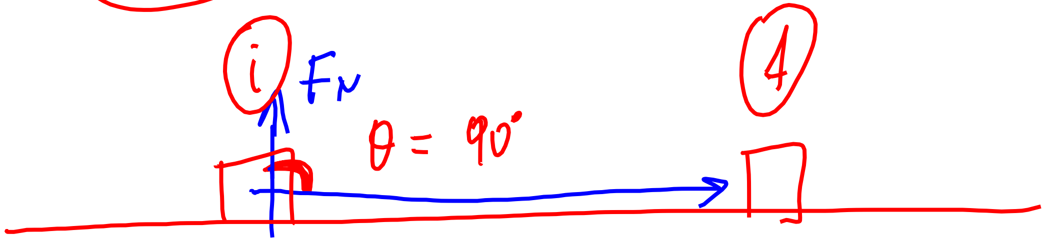
You push a box applying a force (as shown in the picture).

The work done by the *normal* force is …

1. < 0 **2. = 0** **3. > 0**

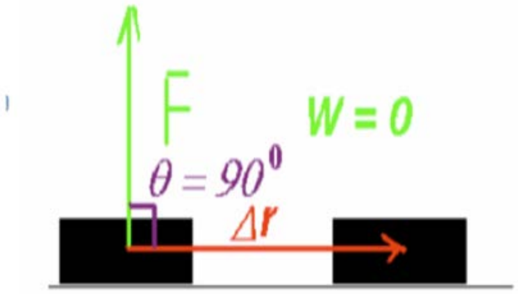
$\cos 90° = \phi$

$W = |F| \cdot |S| \cdot \phi = \phi$ J



Work done by a normal force

$$W_{cF} = |\vec{F}|*|\vec{S}|*\cos\theta$$

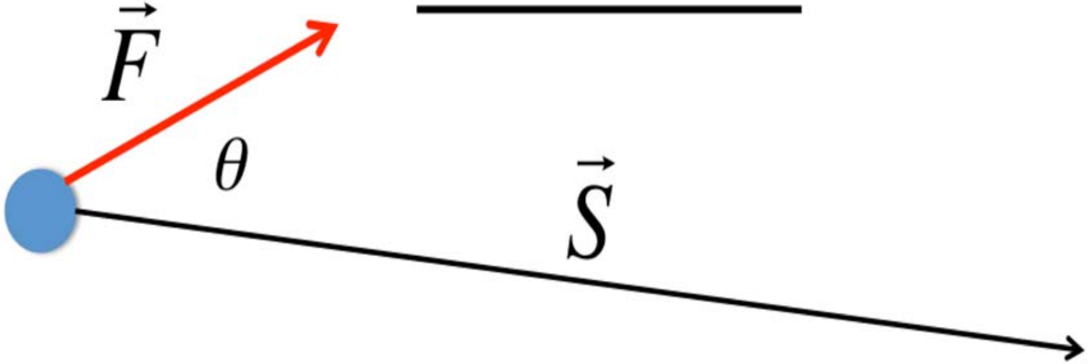


You push a box applying a force (as shown in the picture).

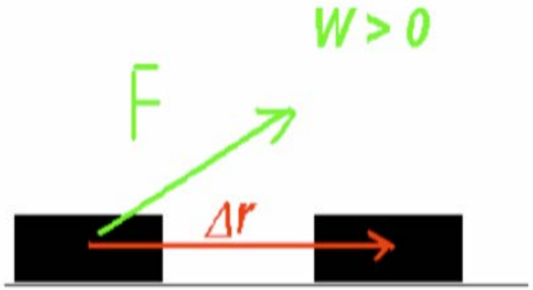
The work done by the *normal* force is …

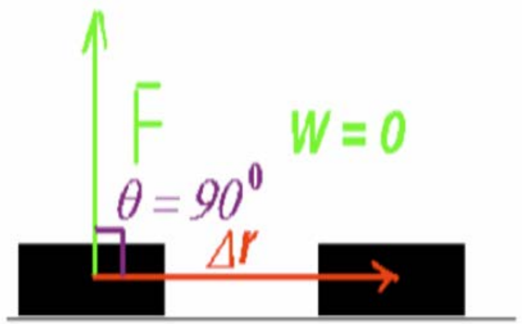
~~1. < 0~~ 2. = 0 ~~3. > 0~~

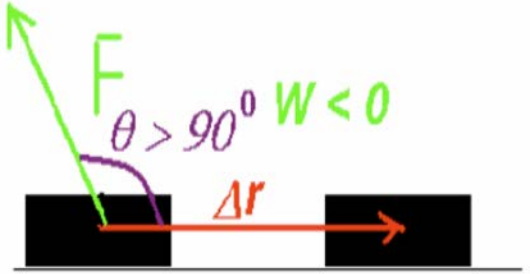
Work done by ANY *constant* force



$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$





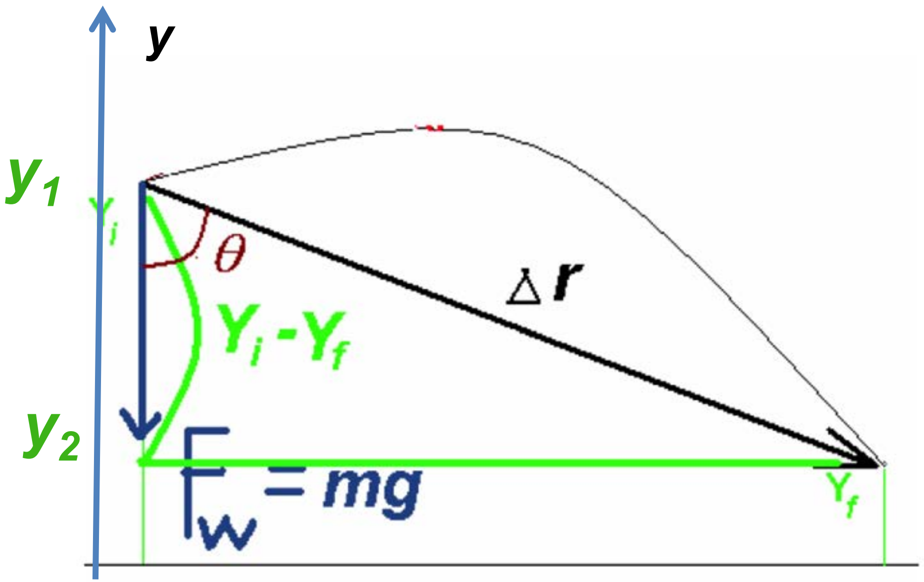


Work done by force of gravity

Drop; Toss; Slide; Project; Shoot; Kick; Push!

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

(y – axis is UP!)



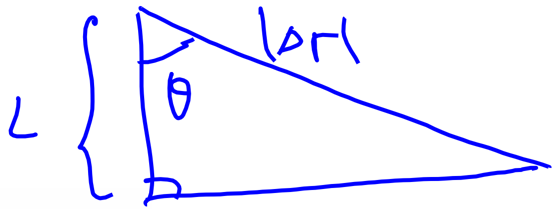
Work done by force of gravity

Drop; Toss; Slide; Project; Shoot; Kick; Push!

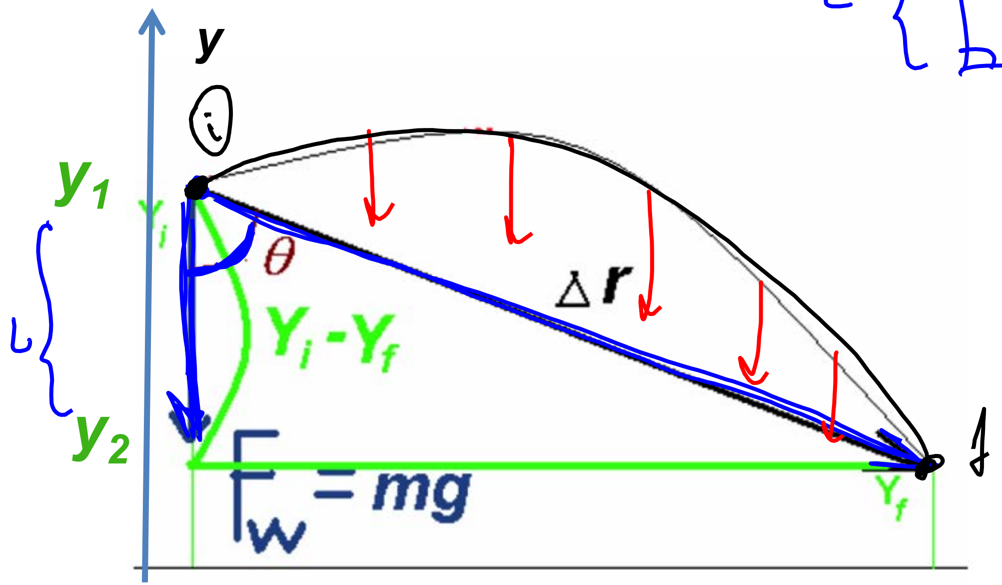
$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

$\vec{F} = m\vec{g} = \text{const.} \Rightarrow W = mg \cdot \overbrace{|\Delta r| \cdot \cos\theta}$

(*y* – axis is UP!)



$|\Delta r| \cdot \cos\theta = L = Y_1 - Y_2$

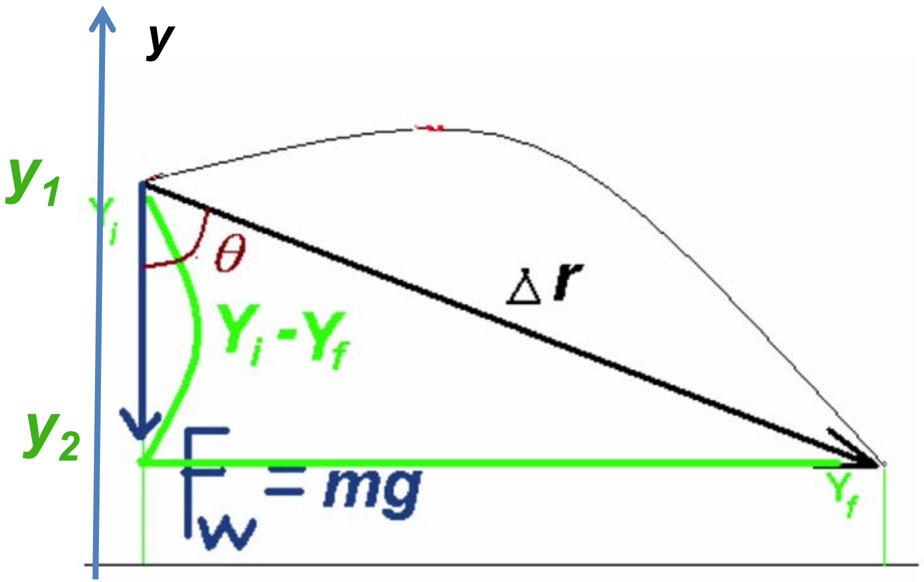


$$\underline{W = mg \cdot (Y_1 - Y_2)}$$

Work done by force of gravity

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

$$W_g = mg \cdot \Delta r \cdot \cos\theta = \underline{mg(y_1 - y_2)}$$



(*y* – axis is UP!)

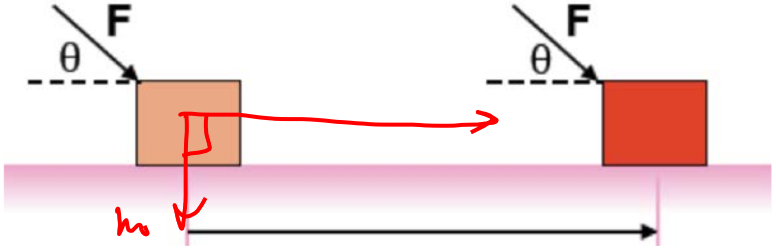
Drop; Slide; Project!

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

You push a 4 kg box 2 m to the right applying 14 N force at 60^0. Find the work done by the force of gravity.

1. -8 J
2. -4 J
3. 0 J
4. 4 J
5. 8 J
6. None of the above

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$

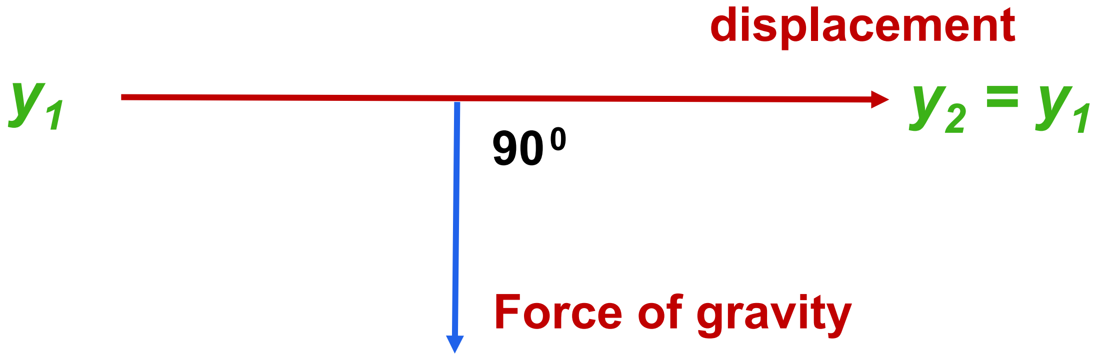


You pushed a 4 kg box 2 m to the right applying 14 N force at 60^0. Find the work done by the force of gravity.

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos 90^0 = 0$$

$$W_g = mg \cdot \Delta r \cdot \cos\theta = mg(y_1 - y_2) = 0$$

1. -8 J
2. -4 J
3. 0 J
4. 4 J
5. 8 J
6. None of the above



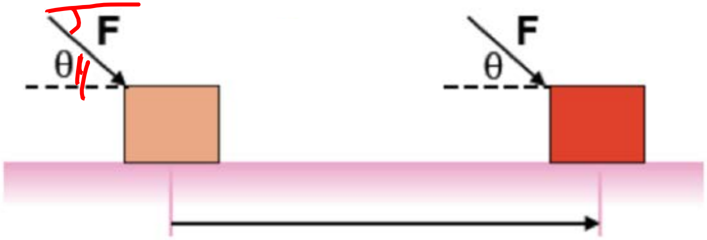
Work done by an applied force

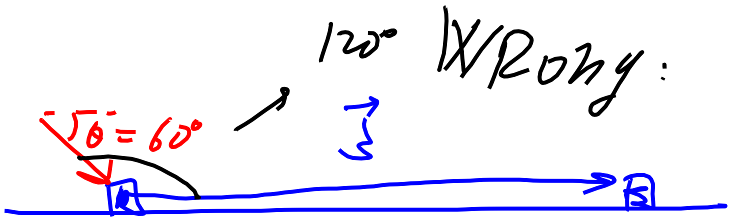
$$W_{cF} = |\vec{F}|*|\vec{S}|*\cos\theta$$

You have been pushing a 4 kg box 2 m to the right applying 14 N force at 60^0 (as shown in the picture). Find the work <u>you</u> did.

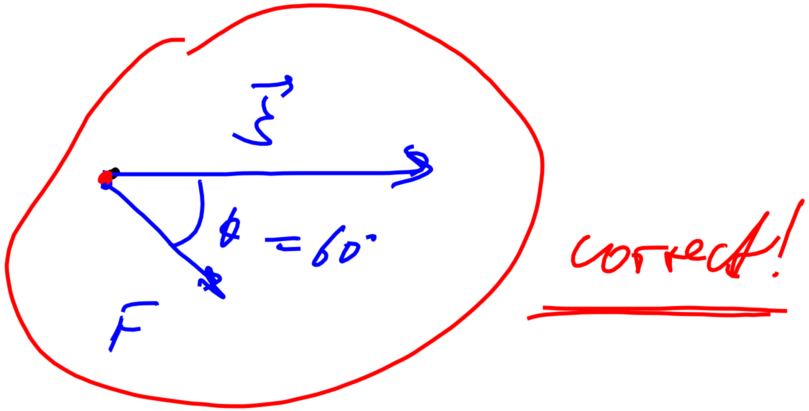
Work done by an applied force

$$W_{cF} = |\vec{F}| * |\vec{S}| * \cos\theta$$



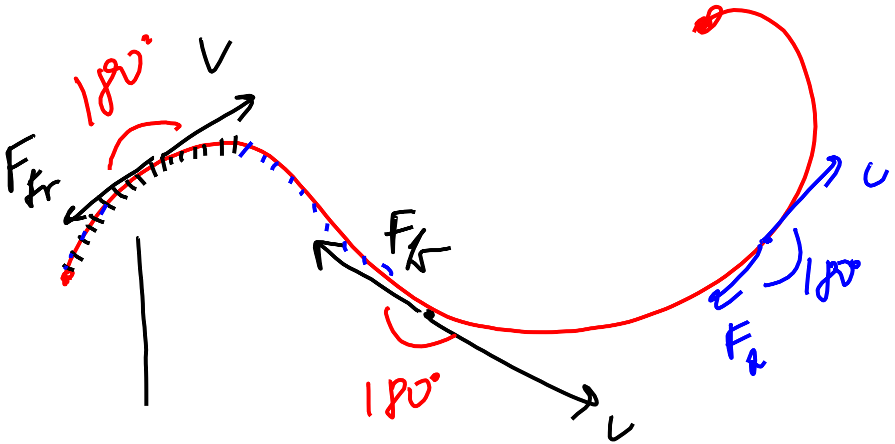


You have been pushing a 4 kg box 2 m to the right applying 14 N force at 60^0 (as shown in the picture). Find the work you did.



$W_{cF} = 14 \cdot 2 \cdot \cos 60° = 14$ J

Work done by force of friction



$|F_{fr}| = \mu_{fr} \cdot F_N$

$\Downarrow$

const

$\Downarrow$

$|F_{fr}| = \text{const}$

$\Delta W = |F_{fr}| \cdot |\Delta X| \cdot \cos 180° = (-1) \cdot \mu_{fr} \cdot F_N \cdot \Delta X$

$\sum \Delta W = (-1) \cdot \mu_{fr} \cdot F_N \cdot \sum \Delta X = \underline{\underline{-\mu F_N \cdot L}}$

Work done by force of friction

$$W_{fr} = |F_{fr}| * |L| * cos(180) = -|F_{fr}| * |L|$$

$$= -\mu_f * F_N * L$$

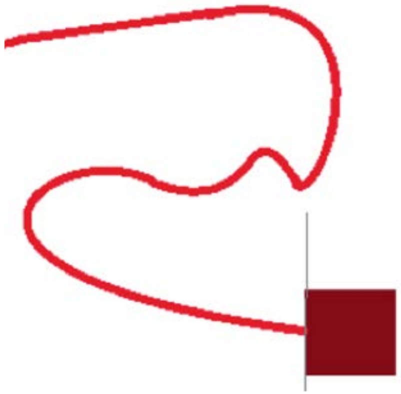
$$W_{fr} = \sum |F_{fr}| * \Delta L * cos(180) =$$

$$= -\sum \mu_f * F_N * \Delta L =$$

$$= -\mu_f * F_N * \sum \Delta L =$$

$$= -\mu_f * F_N * L$$

$$F_{fr} = \mu_k F_N$$

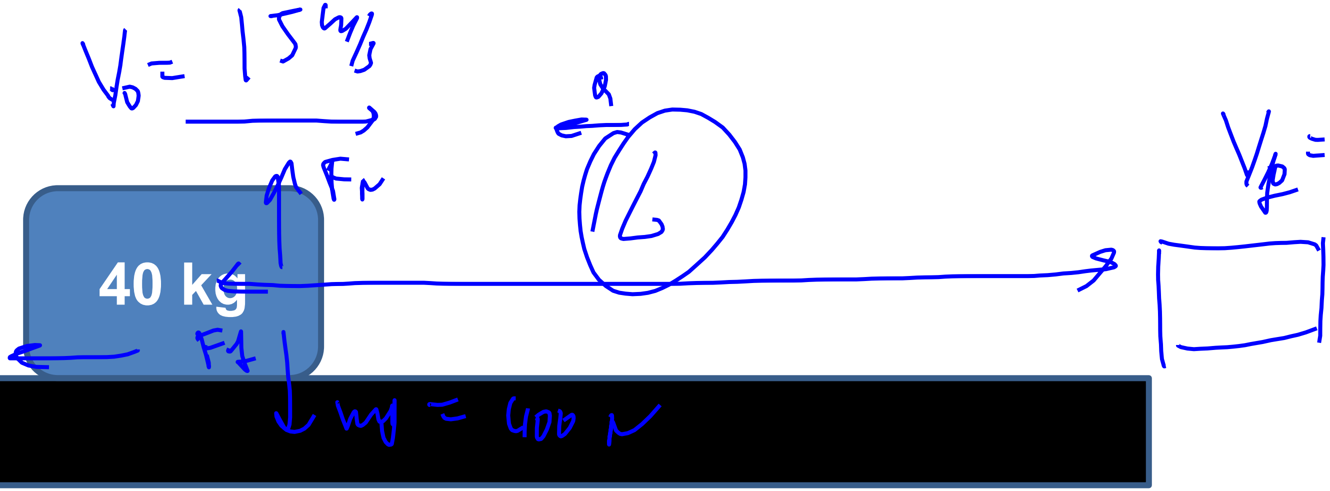


L = the length of the path = the distance traveled

You push<u>ed</u> the box. The initial speed of the box *right after the push* was 15 m/s. If the coefficient of kinetic friction is 0.4, find the work done by the force of friction.

$W_{fr} = -1 \cdot \mu_k \cdot F_N \cdot L =$

$= -1 \cdot 0.4 \cdot 400 \cdot L$



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$L = \frac{15^2}{2 \cdot 4}$