The Science Peer Academic Coaches offer 15-minute sessions to help you feel prepared for your final exams.

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April 2 - 12

Announcement

- We can organize a review session for PHYS 170
- If you are interested: Please think ahead about the topics, problems, techniques, etc. you want to talk about and respond to my post on Piazza
- To make this review more useful, please be specific (“Moments” are not specific enough!!)

Last time:

- **gravitational** potential energy: $V^{(g)}(y) = mgy$

- **elastic** potential energy: $V^{(s)}(x) = \dfrac{k\Delta x^2}{2}$ $\Delta x = x - x_0$

$$\boxed{ME = T + V; \quad V = V^{(g)} + V^{(s)}}$$

Q: Which of the statements below is the work-energy principle?

A. $T_2 = T_1 + \sum U_{1\to 2}^{All}$

B. $T_2 + V_2^{(g)} = T_1 + V_1^{g} + \sum U_{1\to 2}^{(\text{All\_but\_gravity})}$

$V = V^{(g)} + V^{(s)} + V^{(electric)}$

C. $T_2 + V_2 = T_1 + V_1 + \sum U_{1\to 2}^{(\text{non-cons})}$ (V stands for all kinds of potential energy)

D. A and B

E. A, B and C

T = kinetic energy U = work V = potential energy

WORK-ENERGY PRINCIPLE: Once again

$$\underbrace{T_2 + V_2}_{\substack{\text{mechanical}\\ \text{energy at point 2}\\ \text{(final)}}} = \underbrace{T_1 + V_1}_{\substack{\text{mechanical}\\ \text{energy at point 1}\\ \text{(initial)}}} + \sum U_{1\to 2}^{(\text{non}-\text{cons})}$$

Work done by non-conservative forces

$$\boxed{V_1 = V_1^{(g)} + V_1^{(s)}}$$

$$\boxed{V_2 = V_2^{(g)} + V_2^{(s)}}$$

(in PHYS 170, we are not including electric potential energy ☺)

- Note that it is the same as our “old” work-energy principle, $T_2 = T_1 + \sum U_{1\to 2}^{(\text{All})}$.
- We just put it differently: we single out the conservative forces (gravity & elastic force, if applicable) and write down their work explicitly, in the form of the corresponding potential energy

CONSERVATION OF ENERGY

- In general:

$$\underbrace{T_2 + V_2}_{\text{mechanical energy at point 2 (final)}} = \underbrace{T_1 + V_1}_{\text{mechanical energy at point 1 (initial)}} + \sum U_{1\to 2}^{(\text{non-cons})}$$

mechanical energy at point 2 (final)

mechanical energy at point 1 (initial)

Work done by non-conservative forces

- Assume that there are no non-conservative forces (no friction, tension, air drag, pull…) acting on the particle.

Then: $1:\ v_1,\ y_1,\ \Delta x_1$ $\qquad 2:\ v_2,\ y_2,\ \Delta x_2$

$$\boxed{T_1 + V_1 = T_2 + V_2}$$

In words: Mechanical energy of the particle conserves. If a particle's kinetic energy increases by a certain amount as it moves, then its potential energy must decrease by that precise amount and vice versa

- Two-point approach to problem solving: only need to know mechanical energies at points 1 and 2, can ignore the details of motion between these two points

$\vec{N} \perp \Delta\vec{s}$ $\qquad U^{(\vec{N})} = \vec{N}\cdot\Delta\vec{s} = 0$

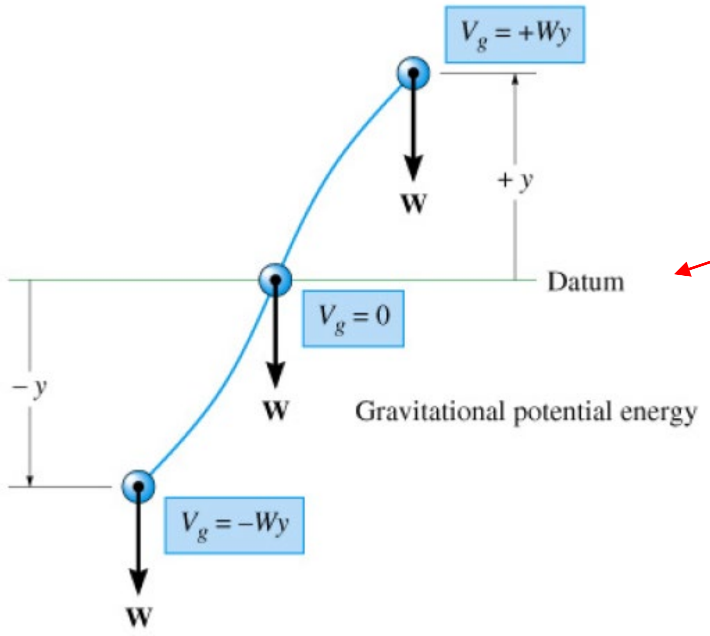
- In presence of non-conservative forces: you need to account for the work done by them on the particle's way

Q: If there is a normal force acting on the particle, can we still use conservation of energy?

ZERO OF POTENTIAL ENERGY

- Kinetic energy, $T = \frac{mv^2}{2}$, is always positive. It is zero when $v = 0$.
- In contrast, for potential energy you have to specify the datum (the zero point of potential energy).

❖ Can be arbitrary point on y-axis (note: we actually will need $U_{1\to2} = V_1 - V_2 = \Delta V$, not its absolute values V_1 and V_2).

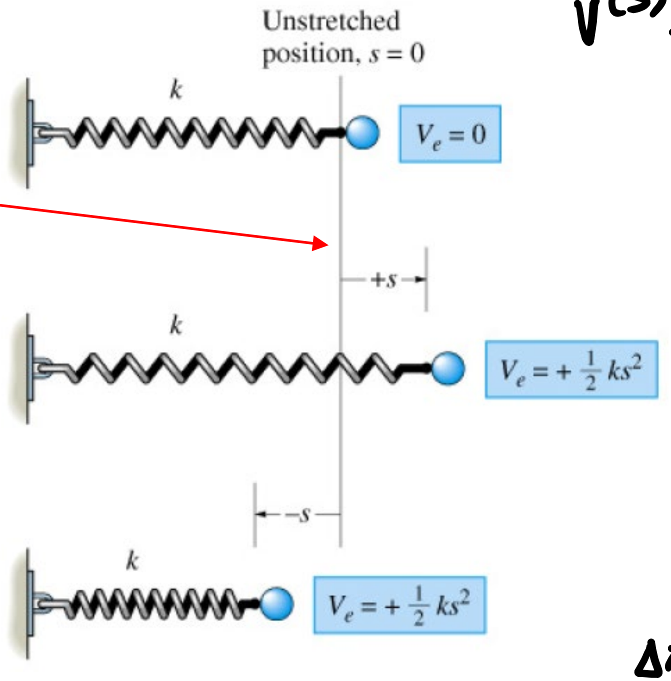


- Gravitational potential energy can be both positive and negative

Datum

❖ At equilibrium (unstretched) position

$V^{(s)} = \frac{k\,\Delta x^2}{2}$

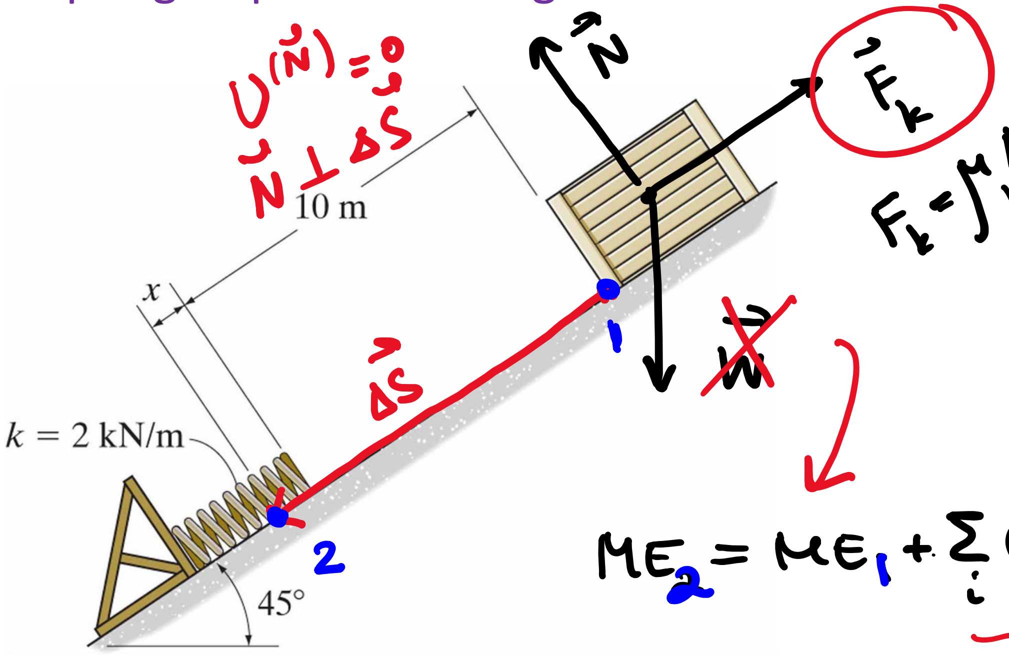


x_0 = unstretched length

$\Delta x = x_0 - x$

- Elastic potential energy is always positive

W11-2. The 100 kg crate slides down the plane. The coefficient of kinetic friction between the crate and the plane is 0.25. The spring is initially unstretched and the crate is initially at rest. Determine the compression of the spring required to bring the crate momentarily to rest.



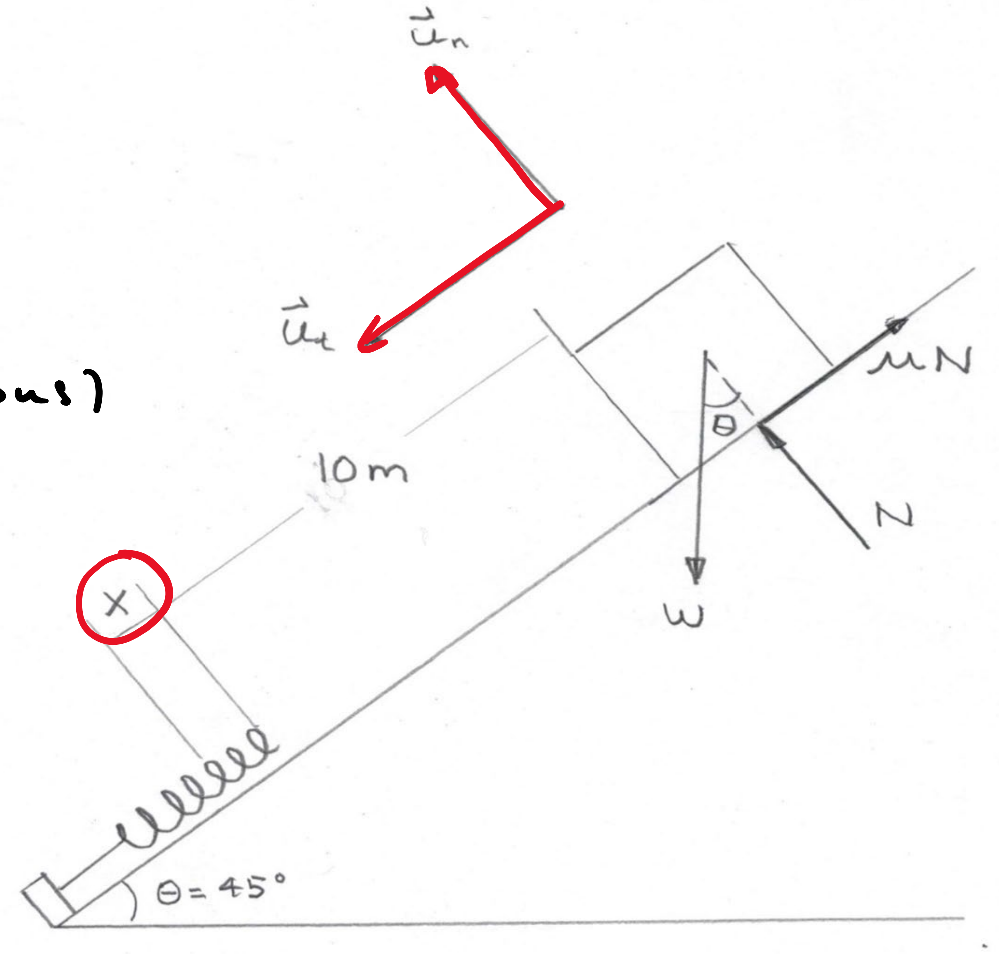
$U^{(\vec{N})} = 0$

$\vec{N} \perp \Delta\vec{s}$

$F_k = \mu_k N$

$U_{1\to 2}^{(\vec{F}_k)}$

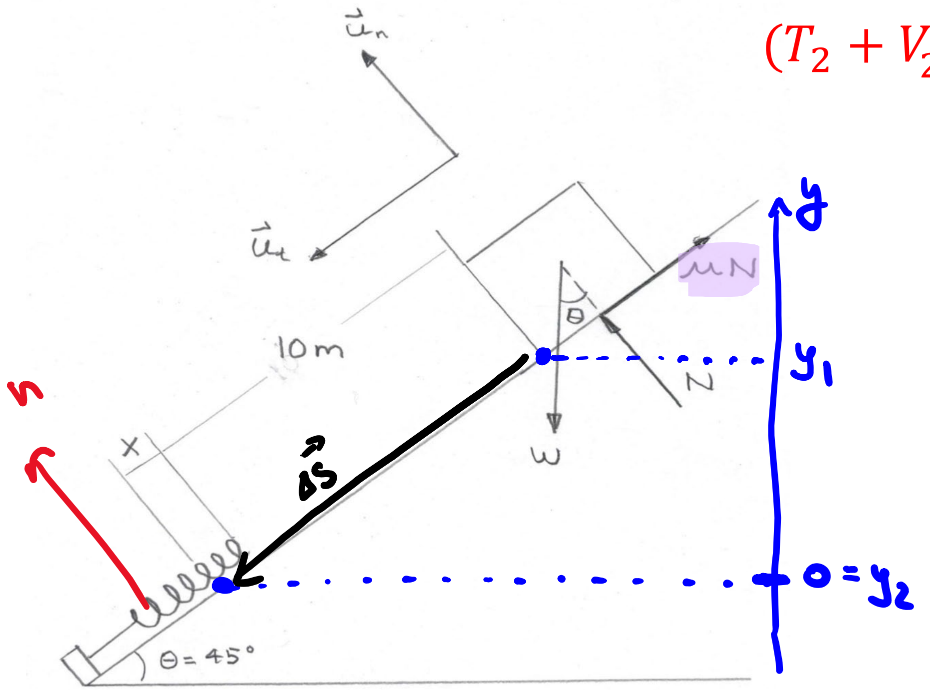
$$ME_2 = ME_1 + \sum_i U_i^{(non-cons)}$$



Q: Does mechanical energy conserve here?

A. Yes!
B. No!
C. IDK

W11-2. The 100 kg crate slides down the plane. The coefficient of kinetic friction between the crate and the plane is 0.25. The spring is initially unstretched and the crate is initially at rest. Determine the compression of the spring required to bring the crate momentarily to rest, if k = 2 kN/m



$$(T_2 + V_2^{(g)} + V_2^{(s)}) = (T_1 + V_1^{(g)} + V_1^{(s)}) + \sum U_{1\to 2}^{\cancel{\text{non-conservative}}\ (F_k)}$$

1: $v_1 = 0$; $y_1 = \Delta S \cdot \sin\theta = (10+x)\sin 45°$; $\Delta x_1 = 0$

2: $v_2 = 0$; $y_2 = 0$ (choice!) ; $\Delta x_2 = x = ?$

$$U_{1\to 2}^{(F)} = \vec{F}\cdot\vec{\Delta S} = F\cdot\Delta S\cdot\cos(180°) = -F\cdot(10+x) =$$

$$= -\mu N(10+x) = -\mu mg\cos 45°(10+x)$$

Equilibrium along n:

$mg\cos\theta = N$

(1) $\left(0 + 0 + \frac{kx^2}{2}\right) = \left(0 + mg(10+x)\sin 45° + 0\right) - \mu mg\cos 45°(10+x)$

x: 2.56 m A. ; ~~−2.03 m~~ B. ; C.

W11-3. The 1.5 kg collar is released from rest at A and travels along the smooth vertical guide. The unstretched length of the spring is 0.1 m. The spring constant is 100 N/m. Determine the following:

x_0

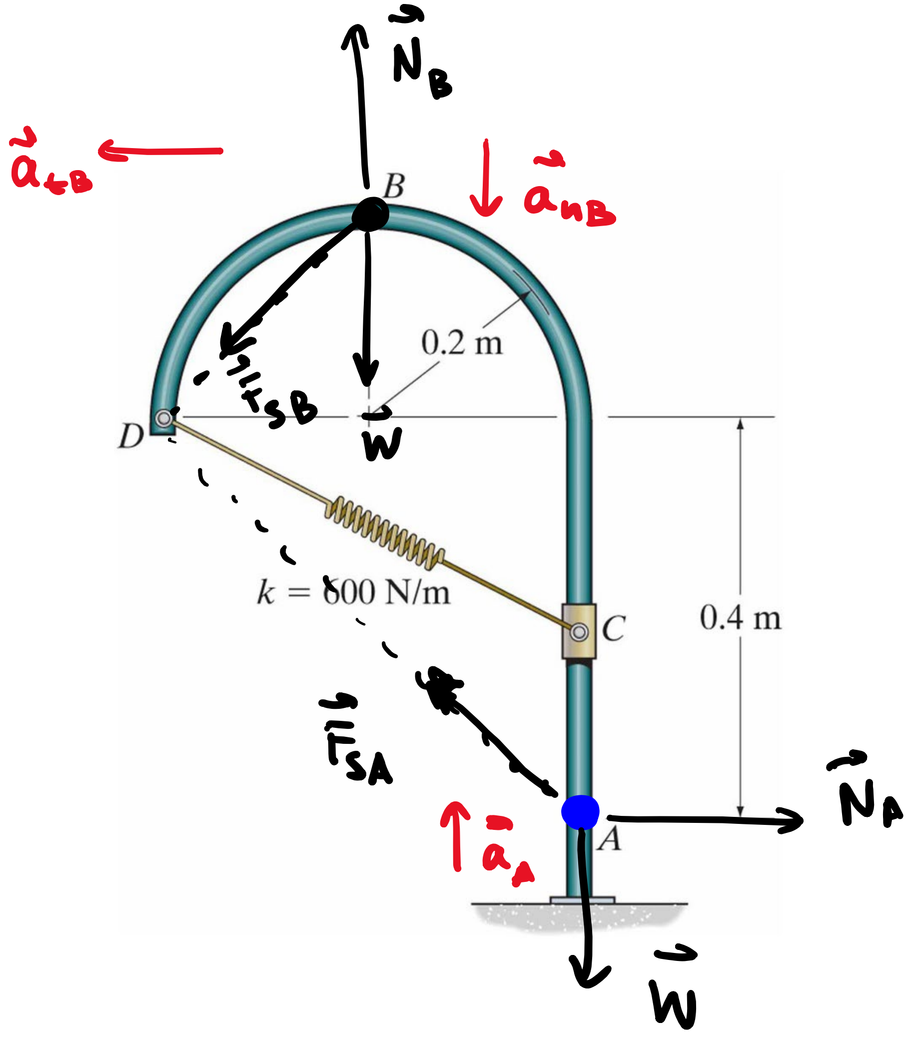
a) The normal force exerted on the collar at A

b) The acceleration of the collar at A

c) The speed of the collar at B

d) The tangential and normal components of the acceleration at B

e) The normal force exerted on the collar at B



$\left.\begin{matrix} F \\ a \end{matrix}\right\}$ – Newton's 2nd law

v_B – WEP (Work-Energy Principle)