College Physics I: 1511 Mechanics & Thermodynamics

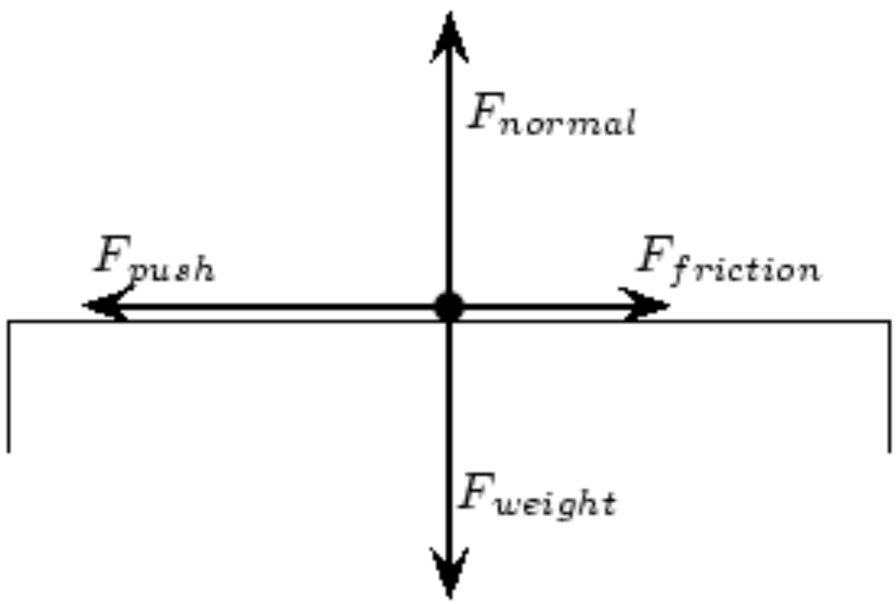
Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Forces

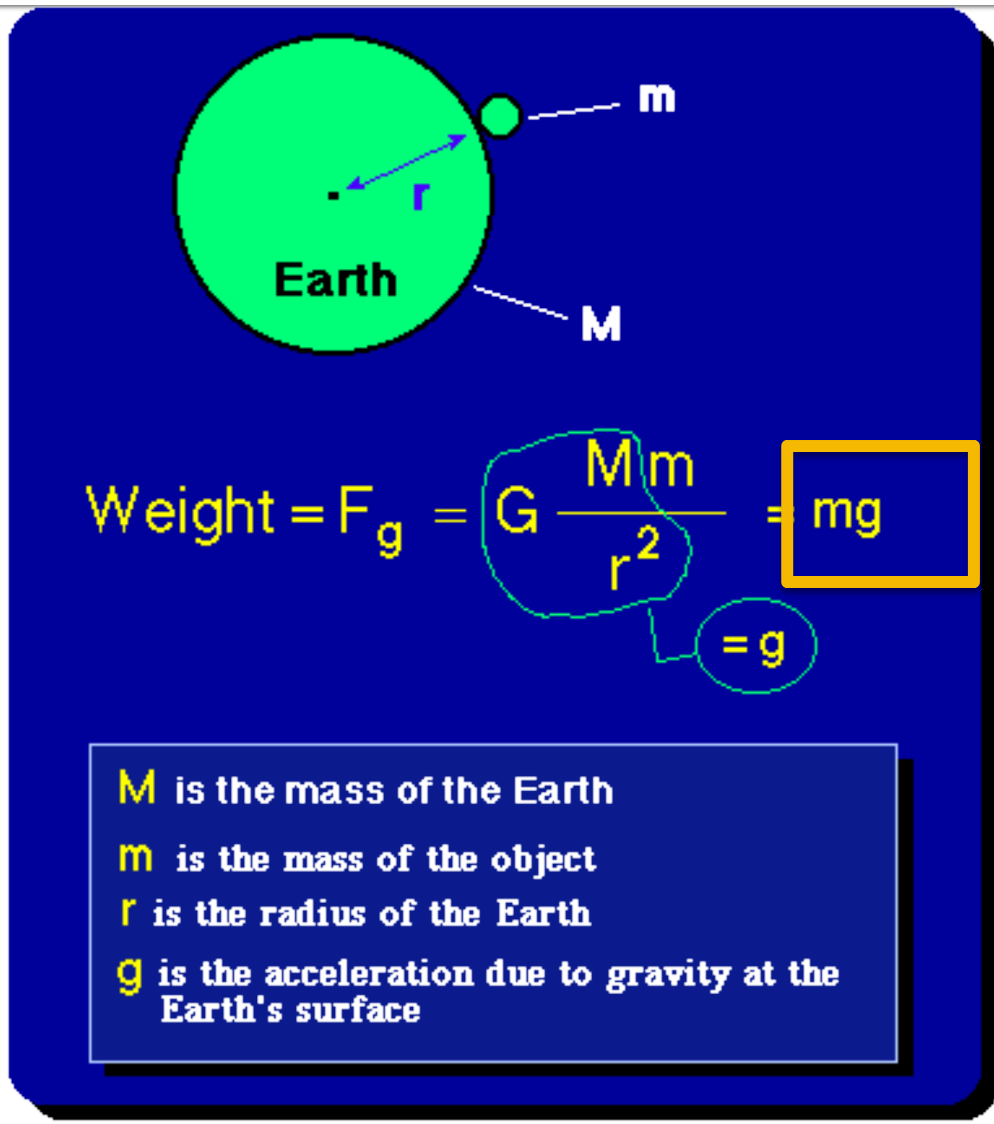
Forces:

$F_G = mg$ (@ surface) $\quad f_s{}^{MAX} = \mu_s F_N \quad f_k = \mu_k F_N$

$F_C = ma_c = \frac{mv^2}{r} \quad F_{spring} = -kx$

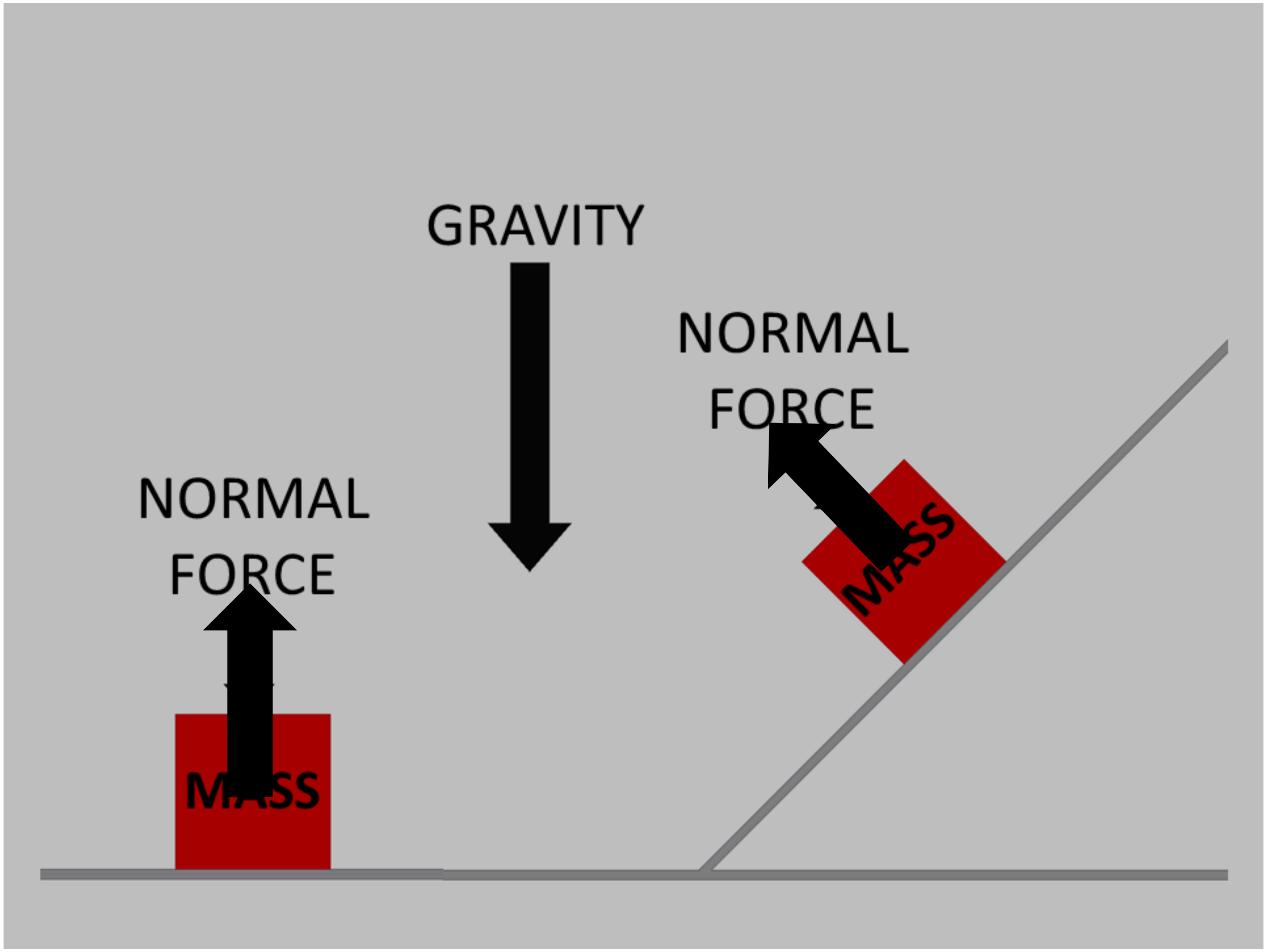


Gravity



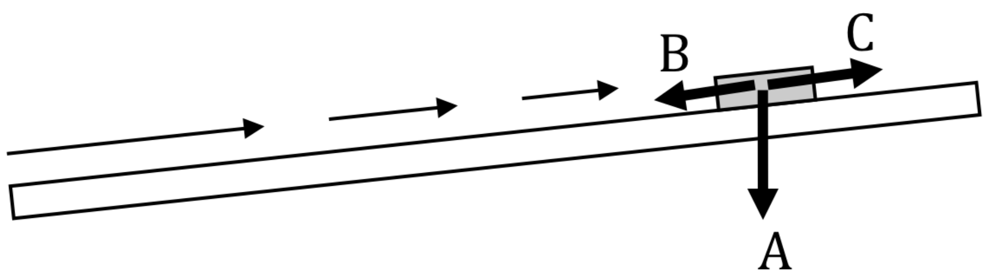
Only need to know gravity at surface for the test!

Normal Forces



Sample Question

A glider on a tilted air track is given a brief push uphill. The glider coasts up to near the top end, stops, and then slides back down.



When the glider is at the highest point of its path, its acceleration is..

A: straight down
B: downward along the track
C: upward along the track

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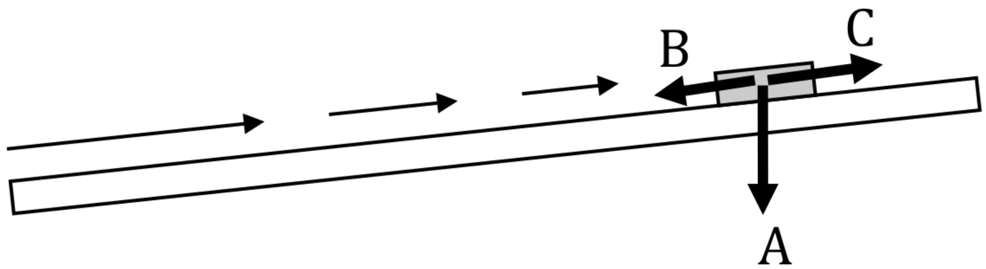


When the glider is at the highest point of its path, its acceleration is..

A: straight down

B: downward along the track

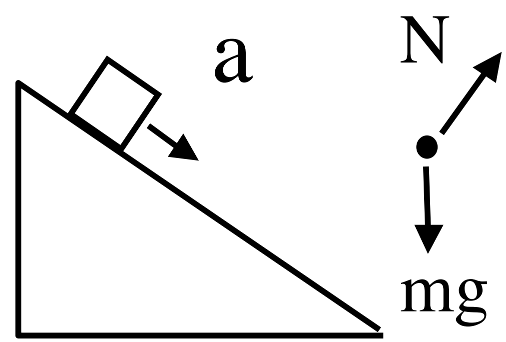
C: upward along the track

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

so $\vec{a}$ down along track

Sample Question

- A mass m is accelerated down along a frictionless inclined plane. The magnitudes of the forces on the free-body diagram have not been drawn carefully, but the directions of the forces are correct. Which statement below must be true?



- A: mg > N
- B: N > mg
- C: N=mg

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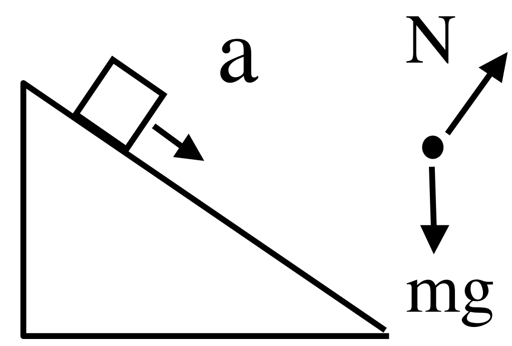
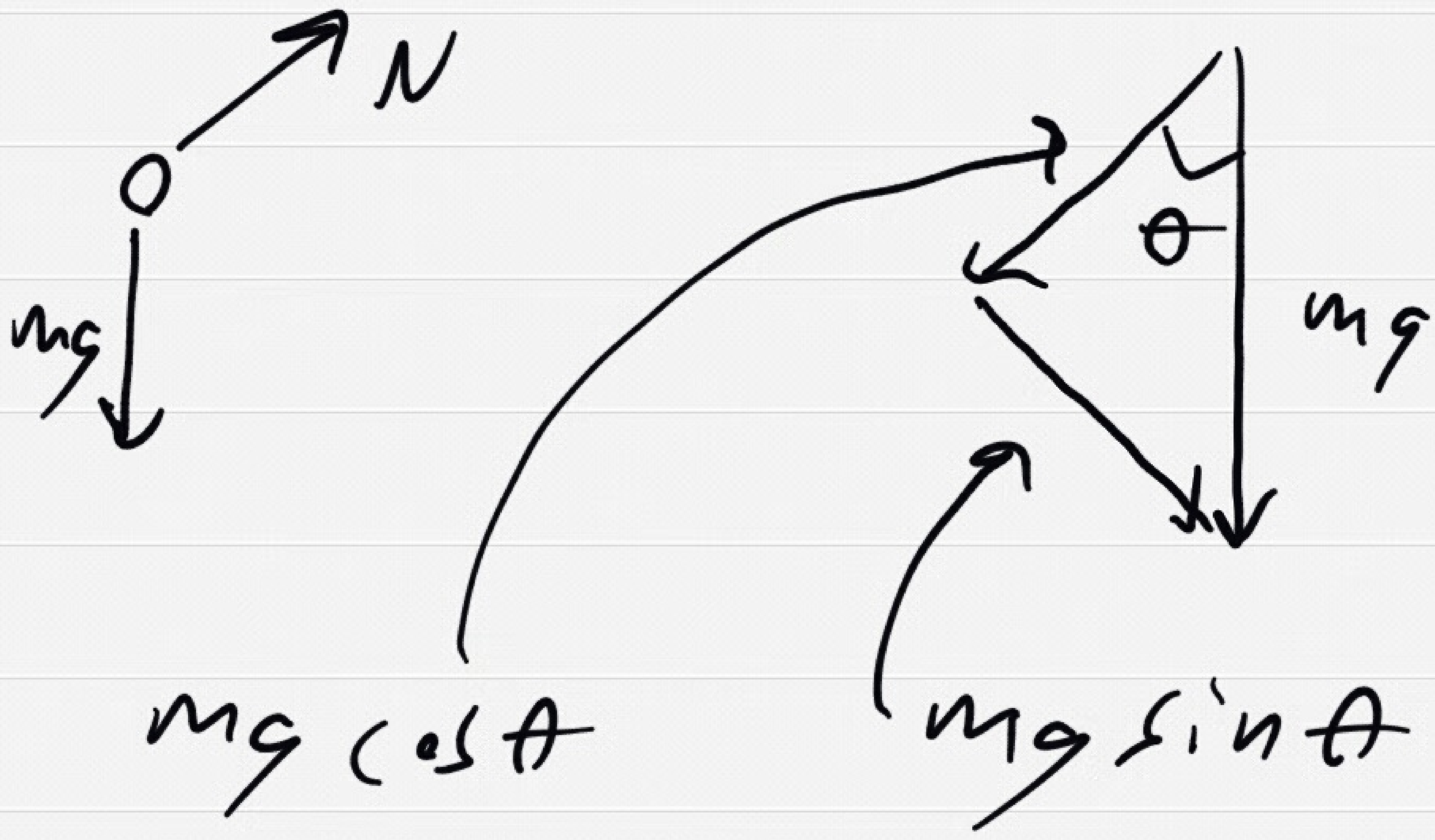


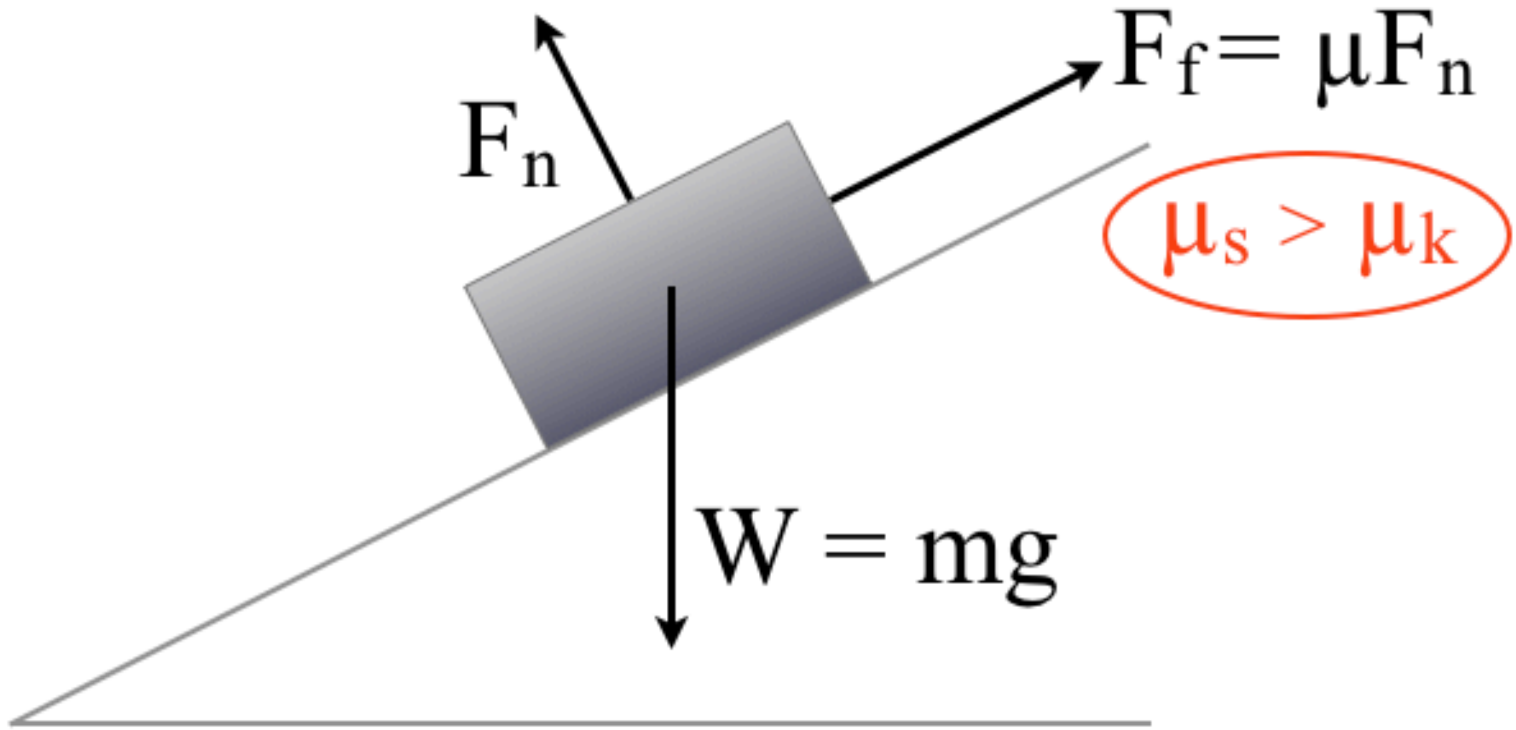
- A: mg > N
- B: N > mg
- C: N=mg



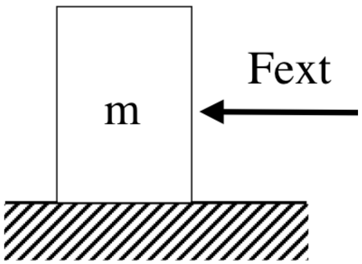
N balances $mg\cos\theta$

so $\boxed{N < mg}$

Friction



Sample Question



I push (with force Fext) on a block (mass m) which sits on the table.
The block is not moving, because there is static friction (coefficient μs).
What can you say for sure about the frictional force, f (frictional force of table on block)?

A: f = μs mg

B: f = Fext

C: f > Fext

D: f < Fext

E: Not enough information (or, MORE than one of the above)

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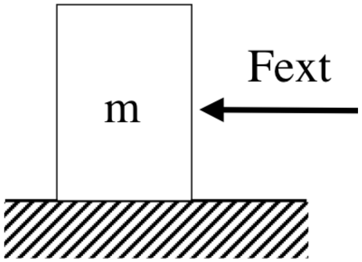

A: f = μs mg

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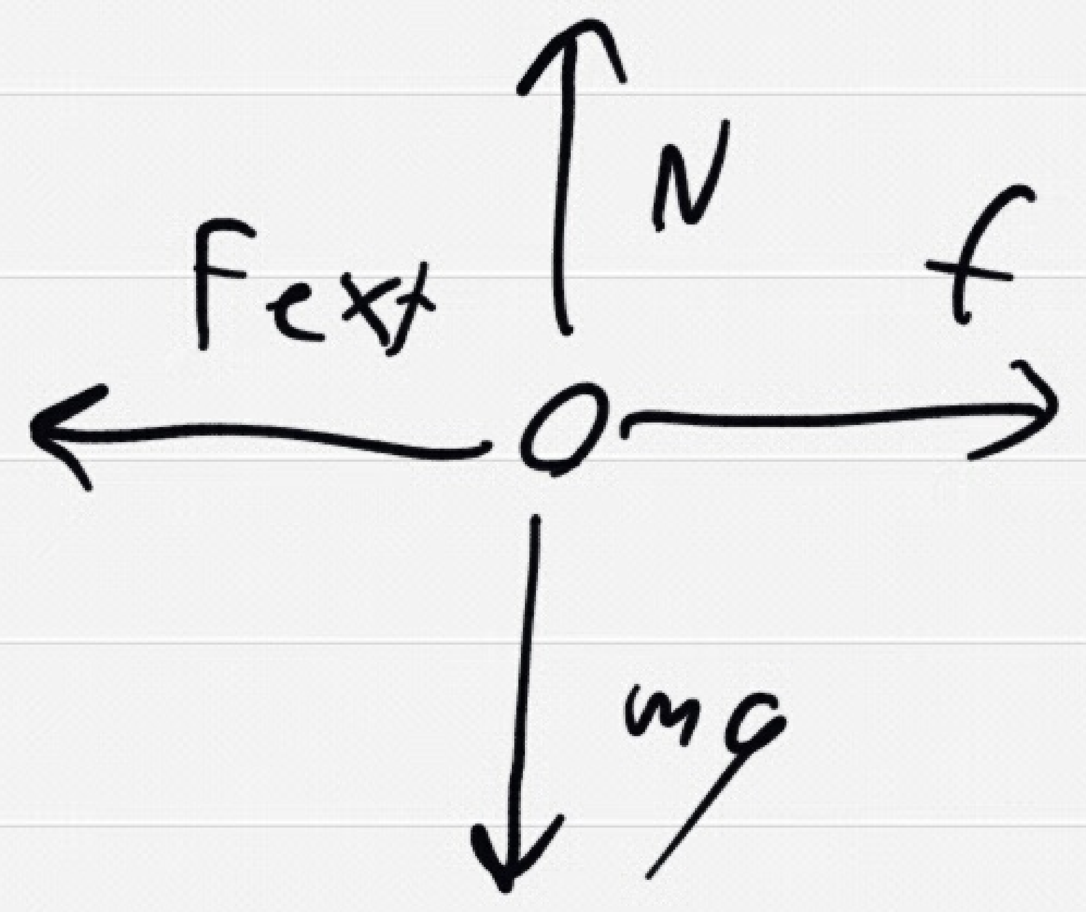


$$\boxed{f = F_{ext}} \quad \text{since } a = 0$$

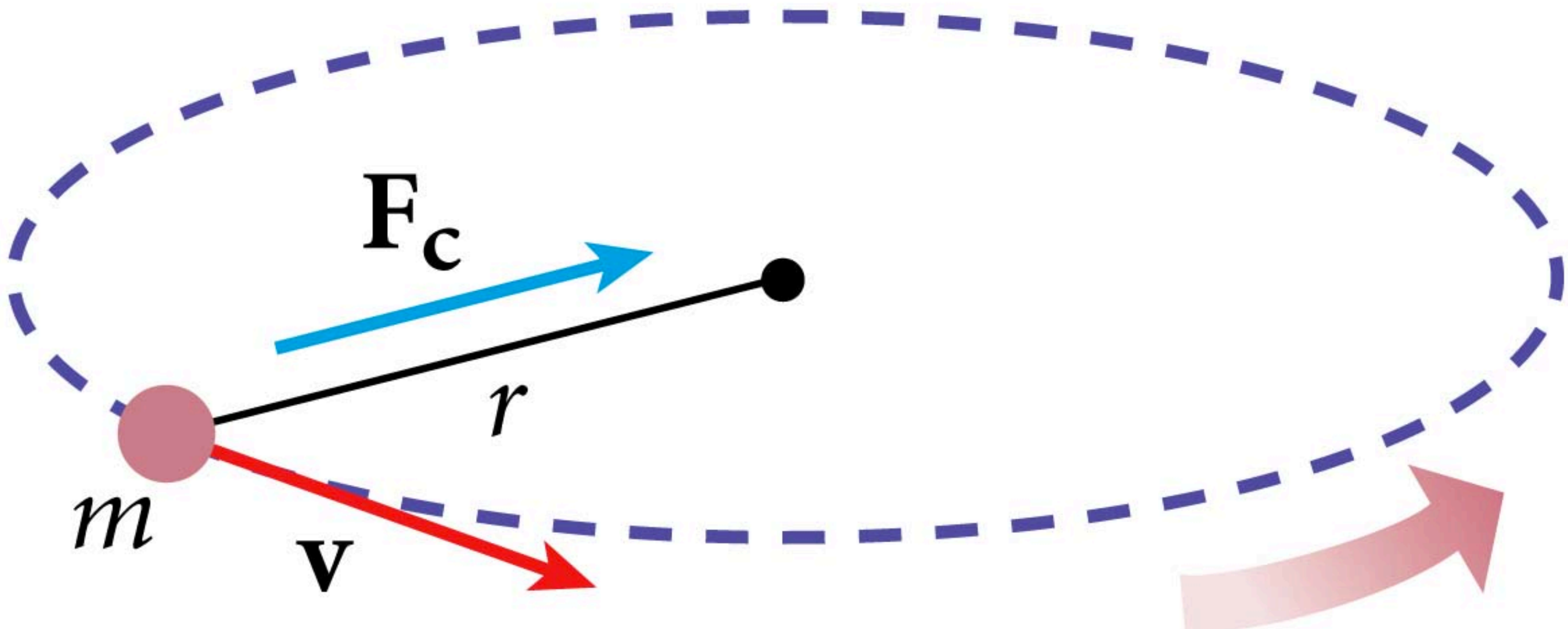
$$f_{max} = \mu_s F_N$$
$$= \mu_s mg$$

but f can be less than f_{max} if not needed to balance F_{ext}

Centripetal Force

Rotational Motion:

$\theta = s/r$ $\qquad a_c = \frac{v^2}{r}$

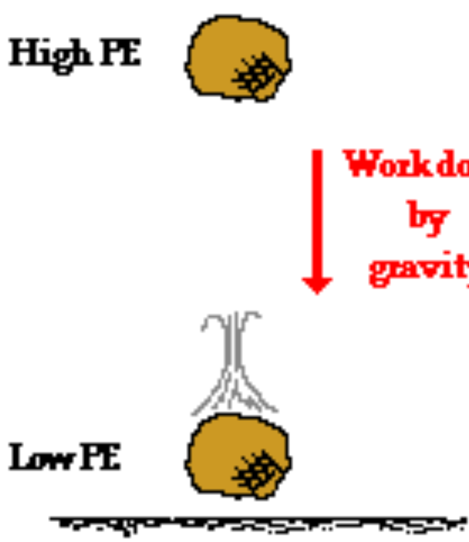


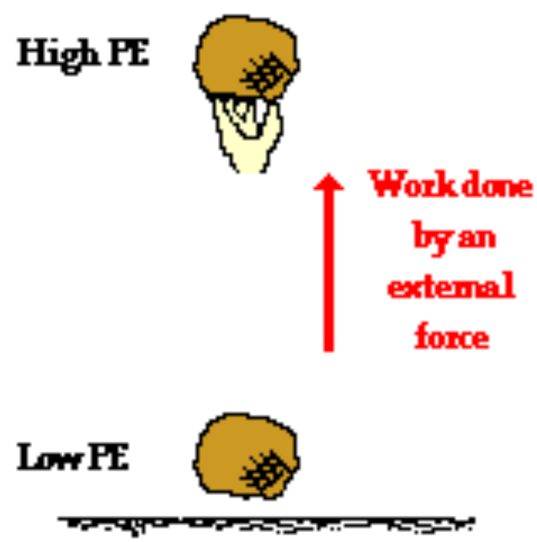
Work and Energy

Work & Energy:

$KE_{trans} = \frac{1}{2}mv^2$ $\Delta KE = W_{net}$ $PE_G = mgh$ $PE_{spring} = \frac{1}{2}kx^2$

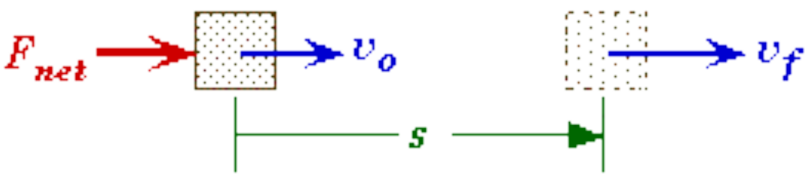
$E = KE + PE$ $\Delta E = W_{nc}$ $W = \vec{F} \cdot \Delta\vec{r} = |\vec{F}||\Delta\vec{r}| \cos\theta_{Fdr}$





Work and Energy

$$KE_o = \frac{1}{2} m v_o^2 \qquad KE_f = \frac{1}{2} m v_f^2$$



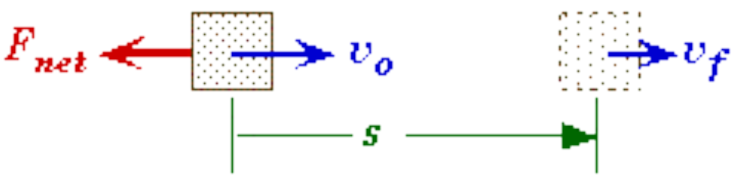
$$W_{net} = F_{net}\, s \cos(0^o) = +F_{net}\, s$$

$W_{net} > 0$

$\Delta v > 0$

$KE_f > KE_o$

$$KE_o = \frac{1}{2} m v_o^2 \qquad KE_f = \frac{1}{2} m v_f^2$$



$$W_{net} = F_{net}\, s \cos(180^o) = -F_{net}\, s$$

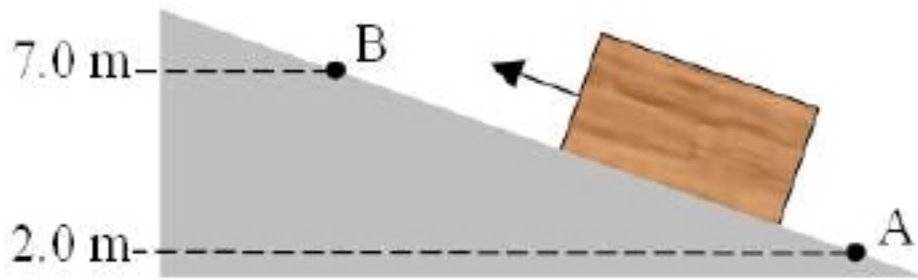
$W_{net} < 0$

$\Delta v < 0$

$KE_f < KE_o$

Sample Question

- A 12-kg crate is pushed up an incline from point A to point B as shown in the figure. What is the change in the gravitational potential energy of the crate? Assume $g = 10\ m/s^2$.



A. –600 J
B. –1200 J
C. +1200 J
D. This cannot be determined without knowing the angle of the incline.
E. +600 J

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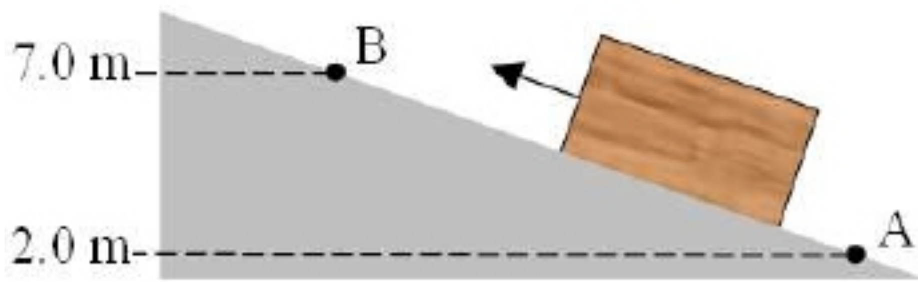

A. –600 J
B. –1200 J
C. +1200 J
D. This cannot be determined without knowing the angle of the incline.
E. +600 J

$$\Delta PE_g = mgh$$

$$= 12 \cdot 10 \cdot 5$$

$$= \boxed{600\ J}$$

Sample Question

- A woman stands on the edge of a cliff and throws a stone vertically *downward* with an initial speed of 10 m/s. The instant before the stone hits the ground below, it has 450 J of kinetic energy. If she were to throw the stone horizontally outward from the cliff with the same initial speed of 10 m/s, how much kinetic energy would it have just before it hits the ground?

- A. 950 J
- B. 50 J
- C. 100 J
- D. 450 J
- E. 800 J

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$$E = KE + PE = \text{const.}$$

$$E_0 = \frac{1}{2} m v_0^2 + mgy_0$$

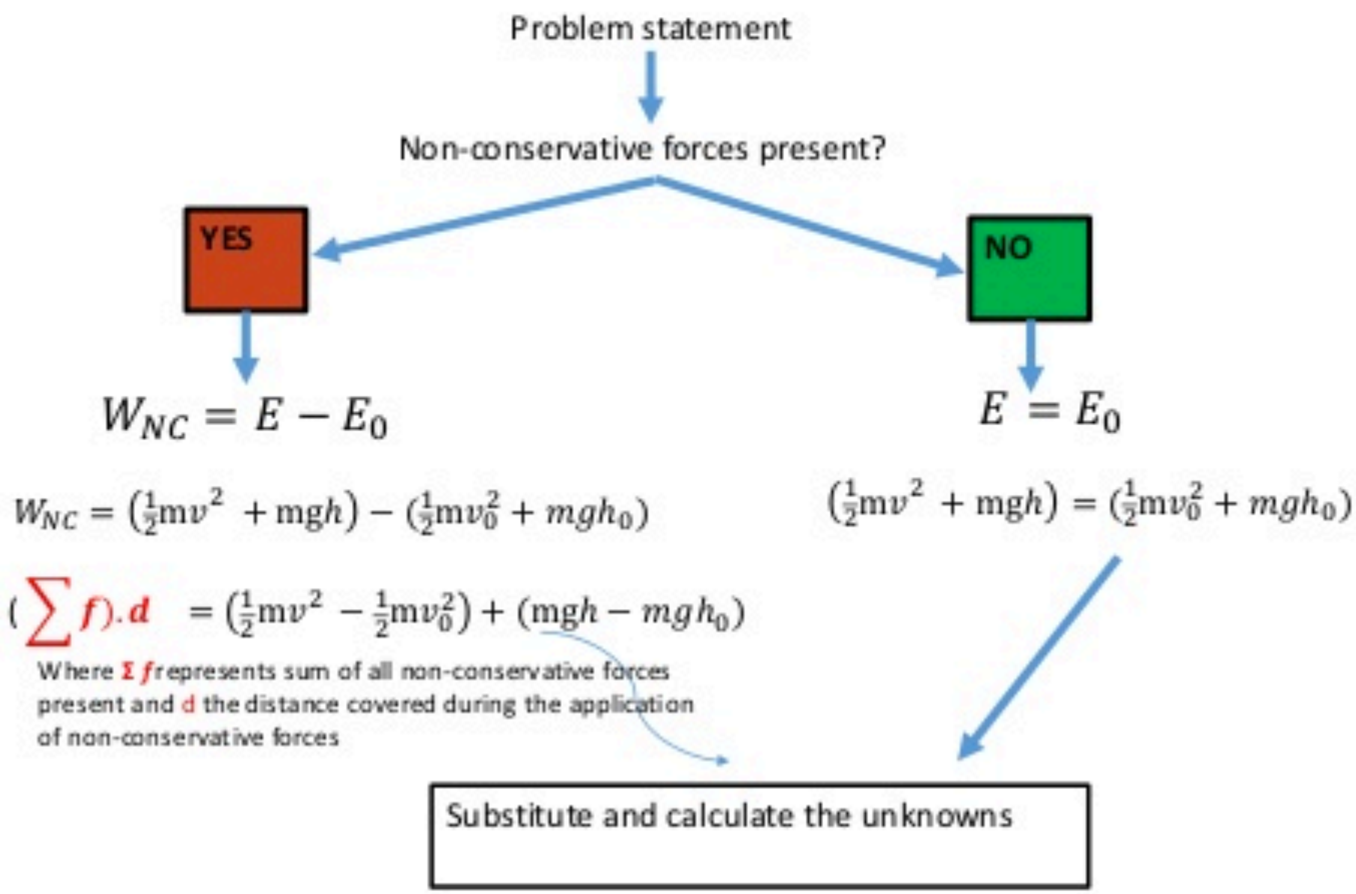
$$E_1 = E_0$$

$$= \frac{1}{2} m v_f^2 + mgy_f$$

KE_f same in both cases

Work and Energy: Non-Conservative

Problem solving strategy



Sample Question

- An automobile approaches a barrier at a speed of 20 m/s along a level road. The driver locks the brakes at a distance of 50 m from the barrier. What minimum coefficient of kinetic friction is required to stop the automobile before it hits the barrier? Assume $g = 10\ m/s^2$.

A. 0.5
B. 0.6
C. 0.4
D. 0.7
E. 0.8

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$$\Delta E = W_{NC} = F \Delta r \cos\theta_{Fr}$$

$$= -F_f \Delta x$$

$$= -\mu m g \cdot 50$$

$$\Delta E = \Delta KE + \Delta PE$$

$$= \Delta \left(\tfrac{1}{2} m v^2 \right)$$

$$= \tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_0^2$$

$$= -\tfrac{1}{2} m v_0^2$$

so $-\tfrac{1}{2} m v_0^2 = -\mu m g \cdot 50$

$$= -500 \cdot \mu \cdot m$$

or $-\tfrac{1}{2} v_0^2 = -500 \mu$

$$\mu = \frac{\tfrac{1}{2} v_0^2}{500} = \frac{\tfrac{1}{2} \cdot 400}{500}$$

$$= \boxed{0.4}$$