Superman

Batman

Bus jump

Space Odyssey

A fall of 100 m

Superman

Batman

Bus jump

Space Odyssey

A fall of 100 m

44 m/s

Superman

Batman

Bus jump

Space Odyssey

A fall of 100 m

44 m/s

Stops over 5 m

Superman

Batman

Bus jump

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2

Batman

Bus jump

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

Batman

Bus jump

Space Odyssey

A fall of 100 m

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

13,000 N

Superman

Batman

Bus jump

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

Batman

13,000 N

Bus jump

50 foot gap

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

Batman

13,000 N

Bus jump

50 foot gap

70 mph

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

Batman

13,000 N

Bus jump

50 foot gap

70 mph

2^{o} incline (generous)

Space Odyssey

A fall of 100 m

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

13,000 N

Superman

Batman

Bus jump

50 foot gap

70 mph

2^o incline (generous)

22 feet

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

Batman

25 m/s

13,000 N

Bus jump

50 foot gap

70 mph

2^o incline (generous)

Space Odyssey

22 feet

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

13,000 N

Batman

25 m/s

0.1 s

Bus jump

50 foot gap

70 mph

2^o incline (generous)

22 feet

Space Odyssey

A fall of 100 m

Superman

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

13,000 N

Batman

25 m/s

0.1 s

140 kg

Bus jump

50 foot gap

70 mph

2^{o} incline (generous)

22 feet

Space Odyssey

A fall of 100 m

44 m/s

Stops over 5 m

193.6 m/s^2 (20 g's)

13,000 N

Superman

Batman

Bus jump

Space Odyssey

25 m/s

0.1 s

140 kg

35,000 N

50 foot gap

70 mph

2^{o} incline (generous)

22 feet

$$U_s = \frac{1}{2}kx^2$$

$$U_g = mgy$$

$$K = \frac{1}{2}mv^2$$

$$\Delta K + \Delta U_s + \Delta U_g + \Delta E_{\mathrm{th}} = W_{\mathrm{net}}$$

$$U_i + K_i + W_{\mathrm{ext}} = U_f + K_f + \Delta E_{\mathrm{th}}$$

$$F_{\mathrm{sp}} = -k\Delta s$$

$$W = \vec{F} \cdot \Delta\vec{r}$$

$$U_s = \frac{1}{2}kx^2$$

$$U_g = mgy$$

$$\Delta E_{\mathrm{th}} = f_{\mathrm{k}}\Delta s$$

$$K = \frac{1}{2}mv^2$$

$$\Delta K + \Delta U_s + \Delta U_g + \Delta E_{\mathrm{th}} = W_{\mathrm{net}}$$

$$U_i + K_i + W_{\mathrm{ext}} = U_f + K_f + \Delta E_{\mathrm{th}}$$

$$F_{\mathrm{sp}} = -k\Delta s$$

$$W = \vec{F} \cdot \Delta\vec{r}$$

$$W = \int \vec{F} \cdot d\vec{r}$$

$$U_s = \frac{1}{2}kx^2$$

$$U_g = mgy$$

$$\Delta E_{\mathrm{th}} = f_{\mathrm{k}} \Delta s$$

$$K = \frac{1}{2}mv^2$$

$$\Delta K + \Delta U_s + \Delta U_g + \Delta E_{\mathrm{th}} = W_{\mathrm{net}}$$

$$U_i + K_i + W_{\mathrm{ext}} = U_f + K_f + \Delta E_{\mathrm{th}}$$

$$F_{\mathrm{sp}} = -k\Delta s$$

$$W = \vec{F} \cdot \Delta\vec{r}$$

$$W = \int \vec{F} \cdot d\vec{r}$$ 1

8 $$U_s = \frac{1}{2}kx^2$$

$$U_g = mgy$$ 6

3 $$\Delta E_{\text{th}} = f_{\text{k}}\Delta s$$

$$K = \frac{1}{2}mv^2$$ 4

$$\Delta K + \Delta U_s + \Delta U_g + \Delta E_{\text{th}} = W_{\text{net}}$$ 9

$$U_i + K_i + W_{\text{ext}} = U_f + K_f + \Delta E_{\text{th}}$$ 7

2

$$F_{\text{sp}} = -k\Delta s$$

5 $$W = \vec{F} \cdot \Delta\vec{r}$$

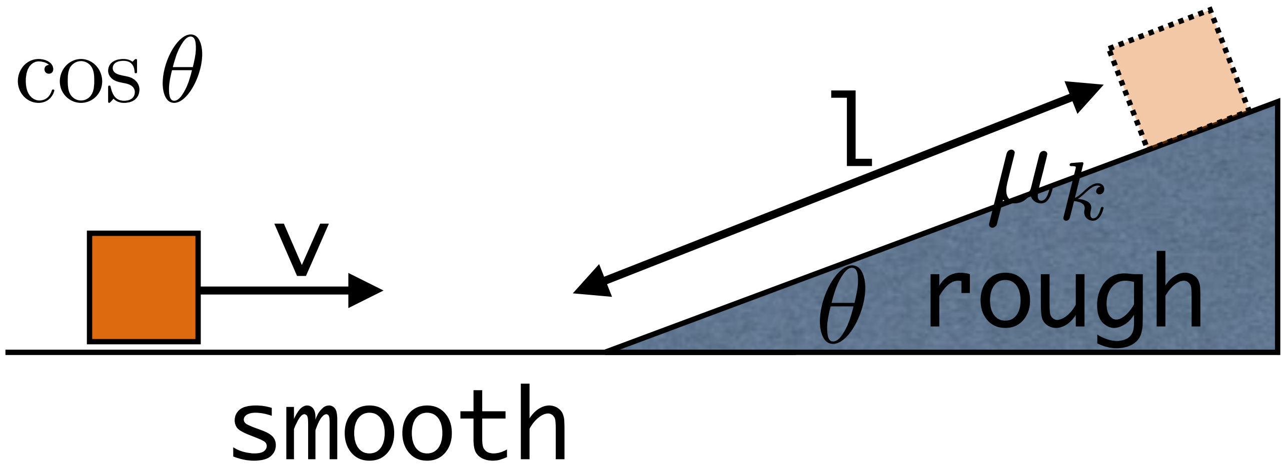
Question #30

Can you determine how far up the incline the box will travel?

A $\frac{1}{2}mv^2 = mgl\cos\theta + \mu_k mg\sin\theta l$

B $\frac{1}{2}mv^2 = mgl\sin\theta + \mu_k mg\cos\theta l$

C $\frac{1}{2}mv^2 = mgl\sin\theta + \mu_k mg\cos\theta$



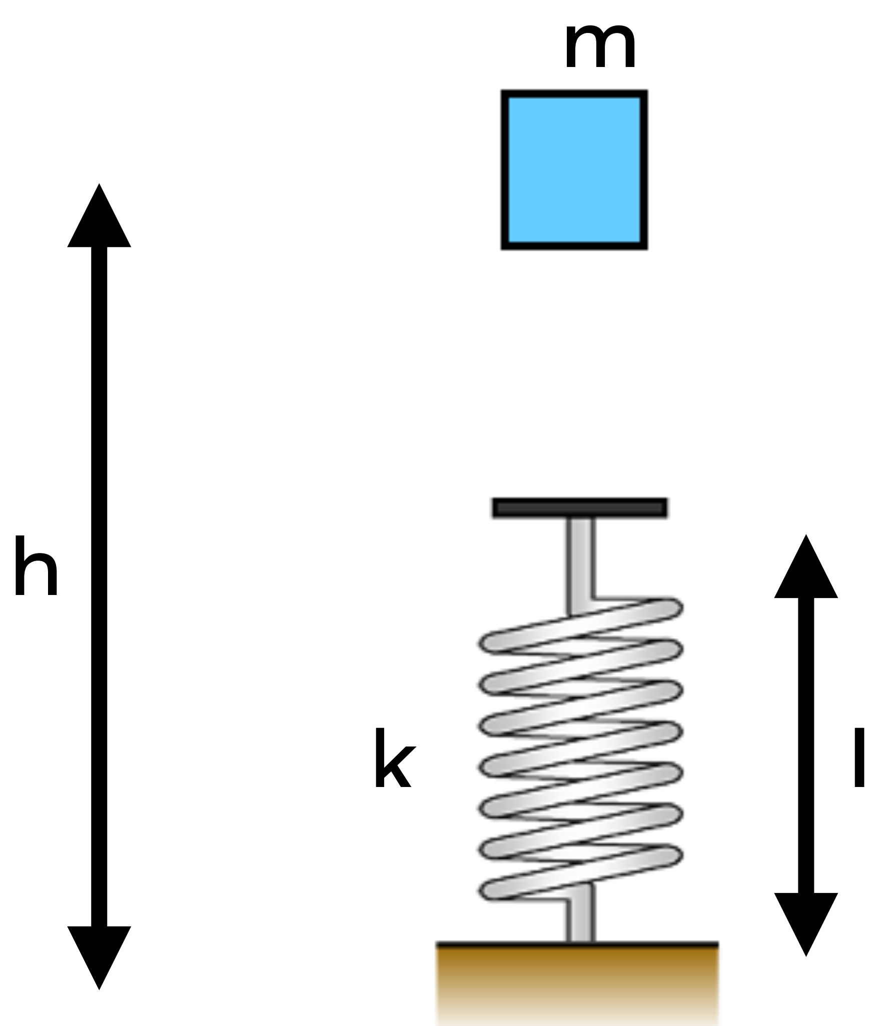
D $\frac{1}{2}mv^2 = mgl\sin\theta + \mu_k mg\sin\theta l$

$$U_i + K_i + W_{\text{ext}} = U_f + K_f + \Delta E_{\text{th}}$$

Spring potential energy

Question #31

By how much does the spring compress?



A $$mgh = \frac{1}{2}kx^2$$

B $$mgh = \frac{1}{2}kx^2 + mg(l - x)$$

C $$mgh = \frac{1}{2}kx^2 + mgl$$

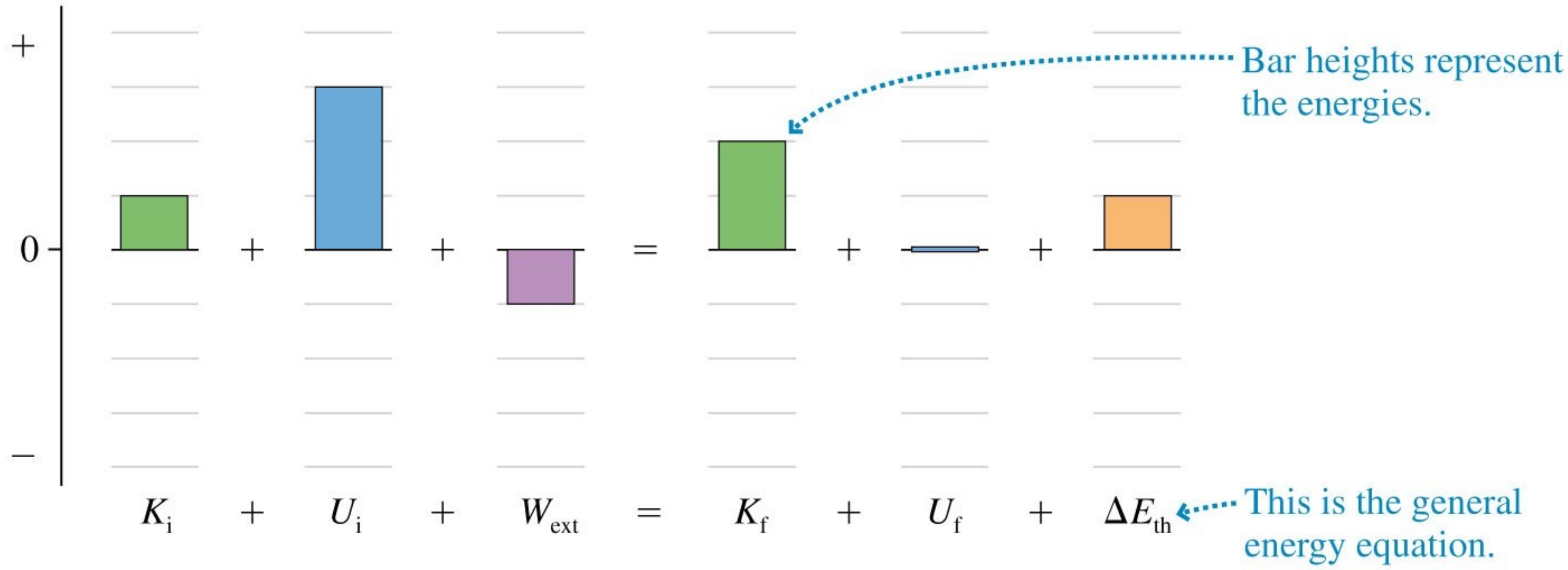
D $$mgh = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$

$$U_i + K_i + W_{\text{ext}} = U_f + K_f + \Delta E_{\text{th}}$$

Energy bar charts

$$U_i + K_i + W_{\text{ext}} = U_f + K_f + \Delta E_{\text{th}}$$

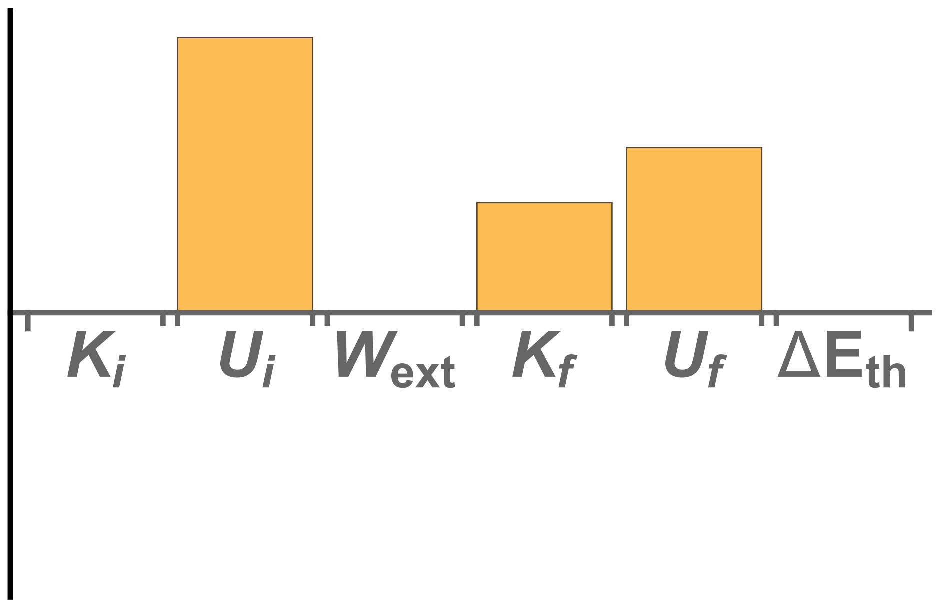
Graphical representation of conservation of energy



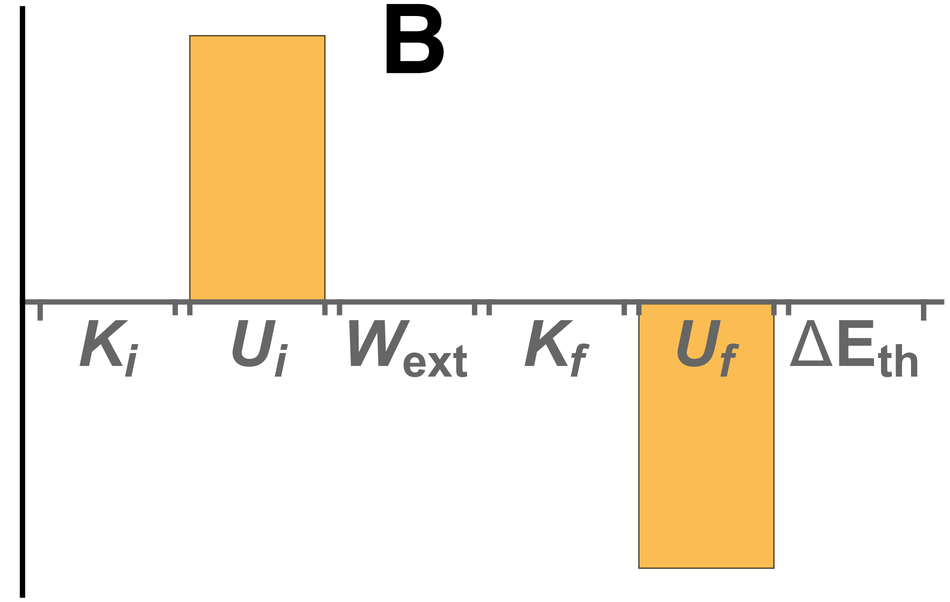
Energy Bar Charts

Question #32

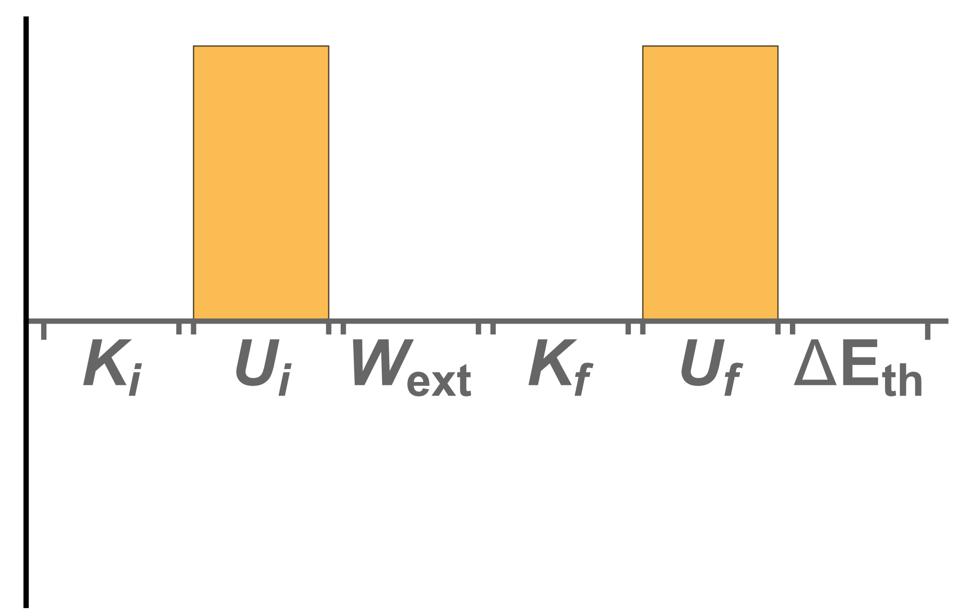
A

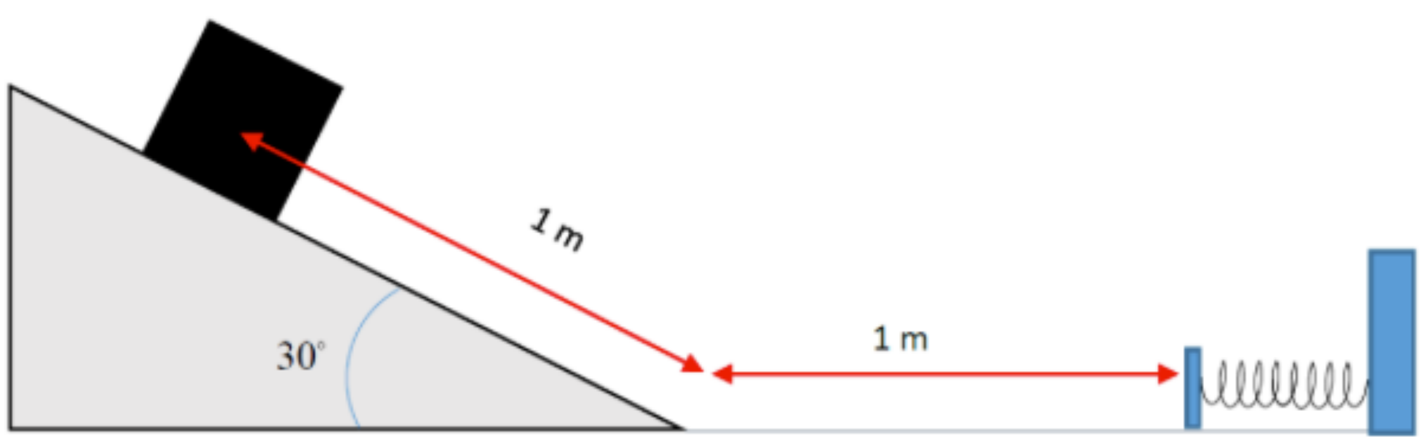


B



C

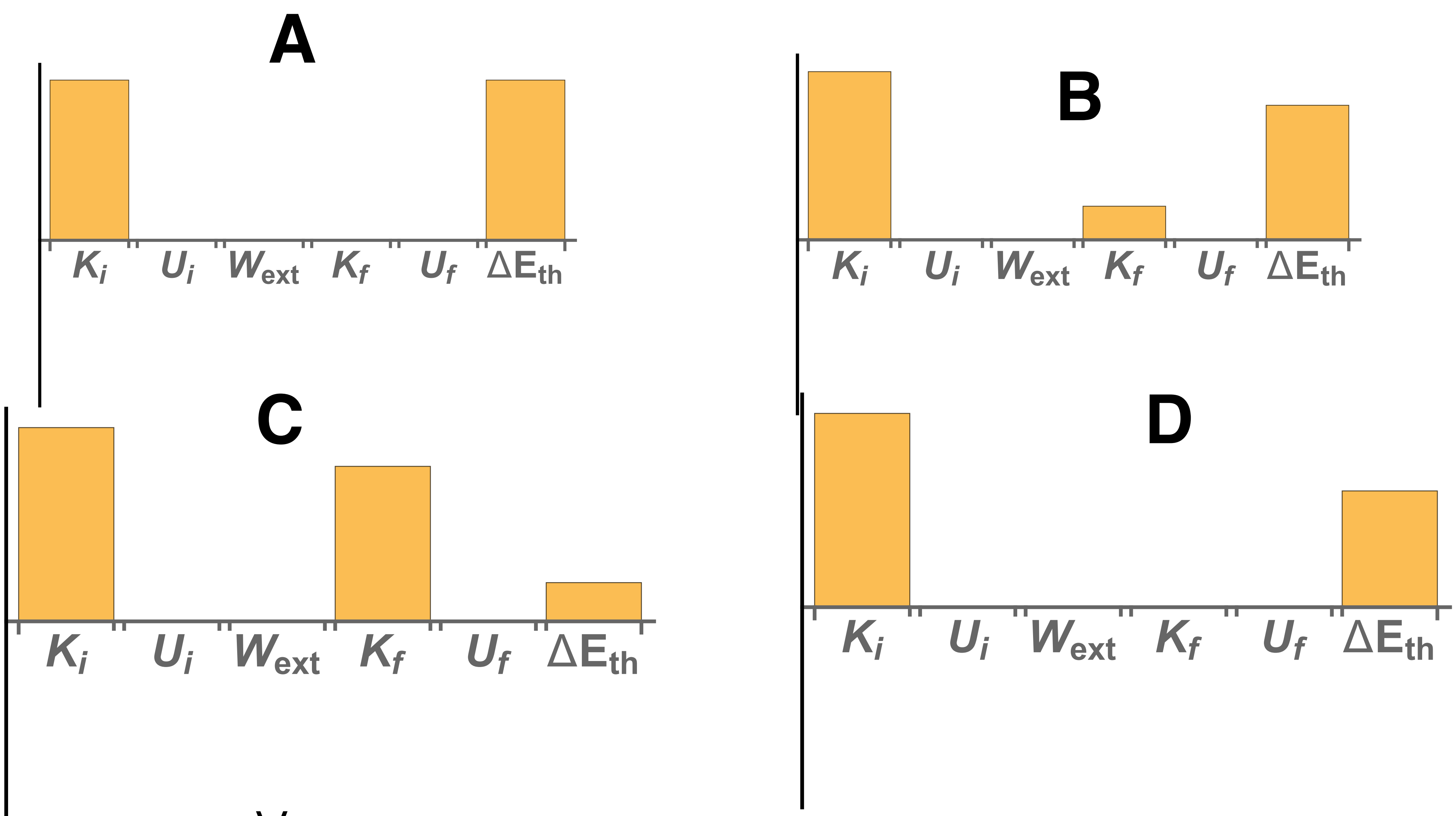


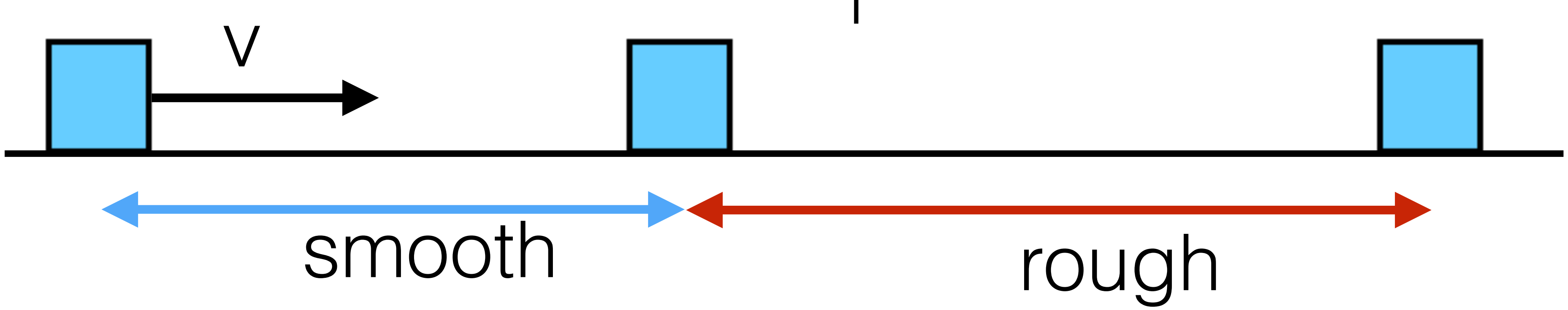


Energy Bar Charts

Question #33

How far does the box slide before coming to rest?



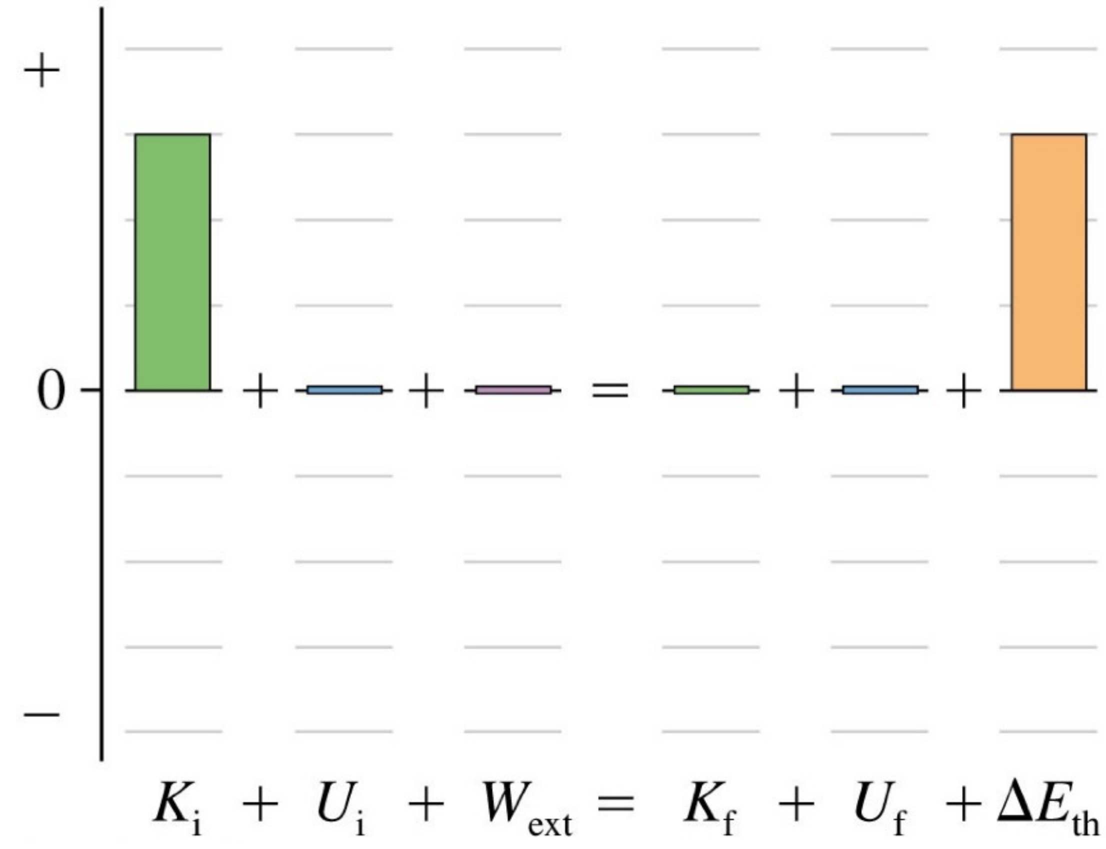


Try a few

A speeding car skids to a halt.

Try a few

A speeding car skids to a halt.

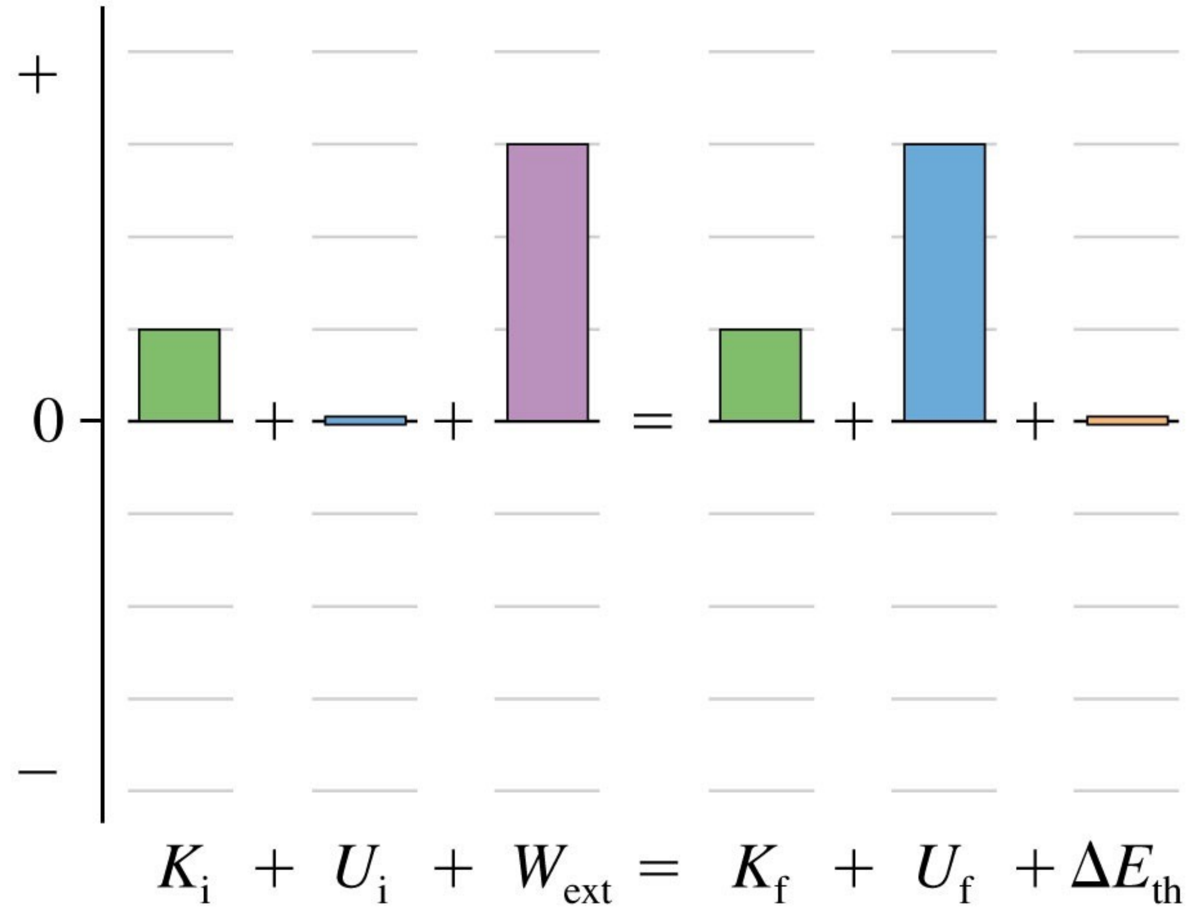


Try a few

A rope lifts a box at constant speed

Try a few

A rope lifts a box at constant speed

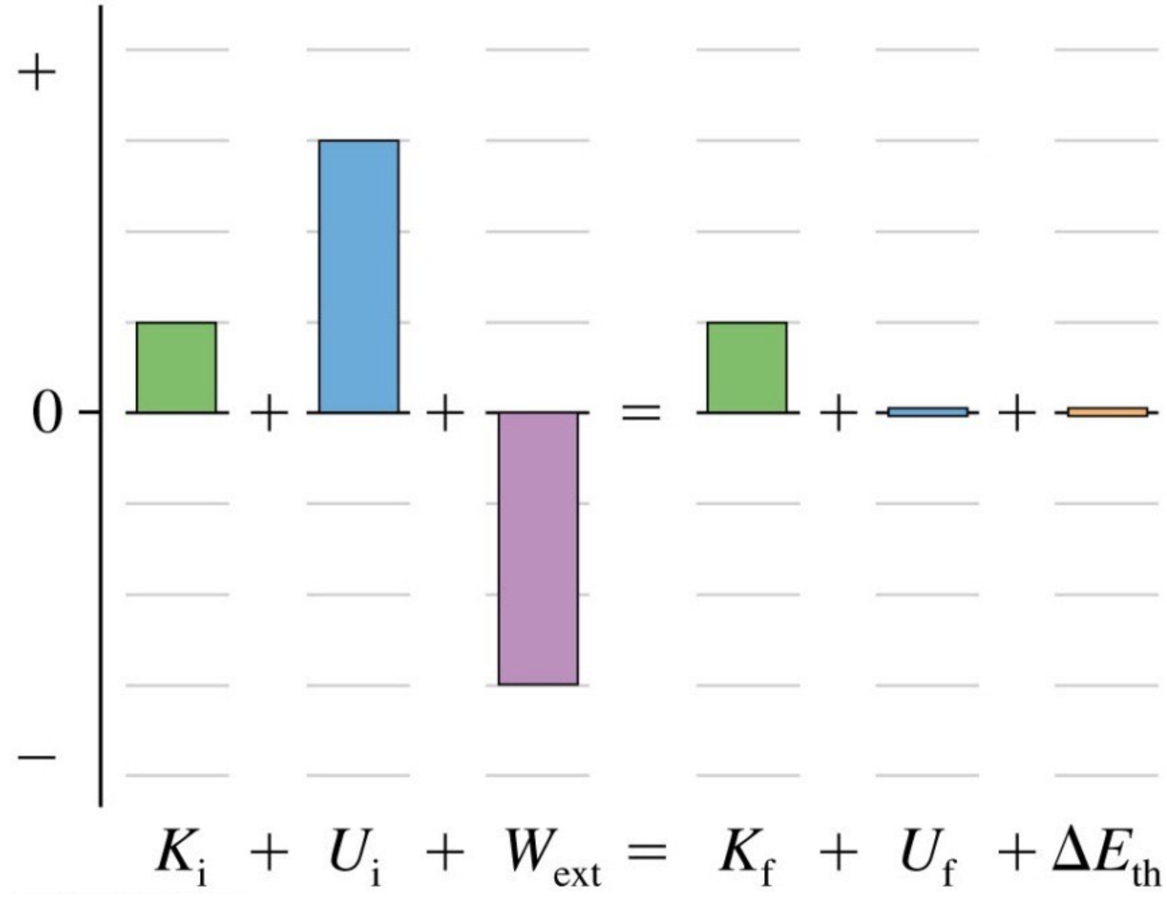


Try a few

The box falls at steady speed as the rope spins a generator and causes a lightbulb to glow.

Try a few

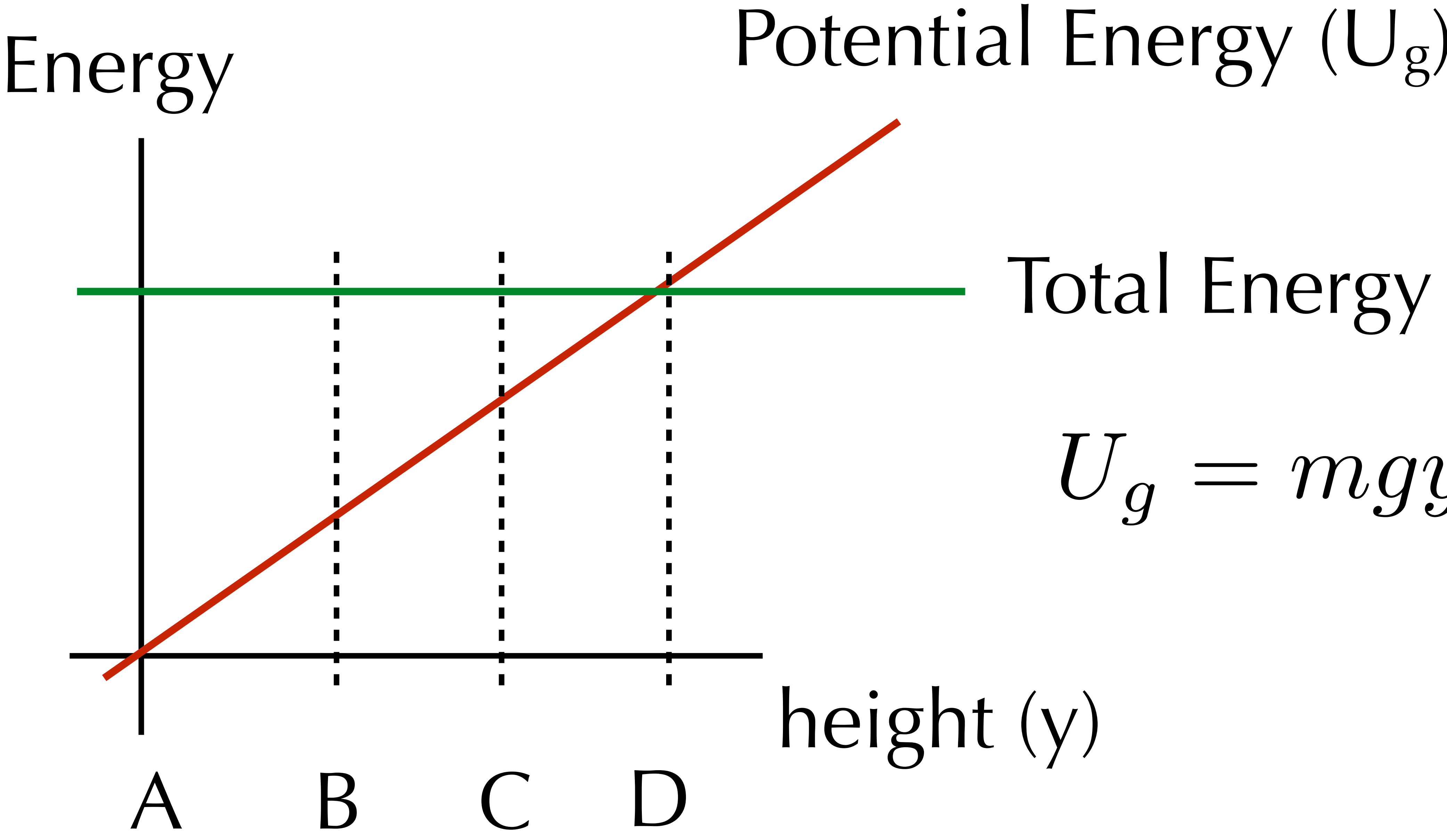
The box falls at steady speed as the rope spins a generator and causes a lightbulb to glow.



Energy diagram for ball thrown upward

Question #37

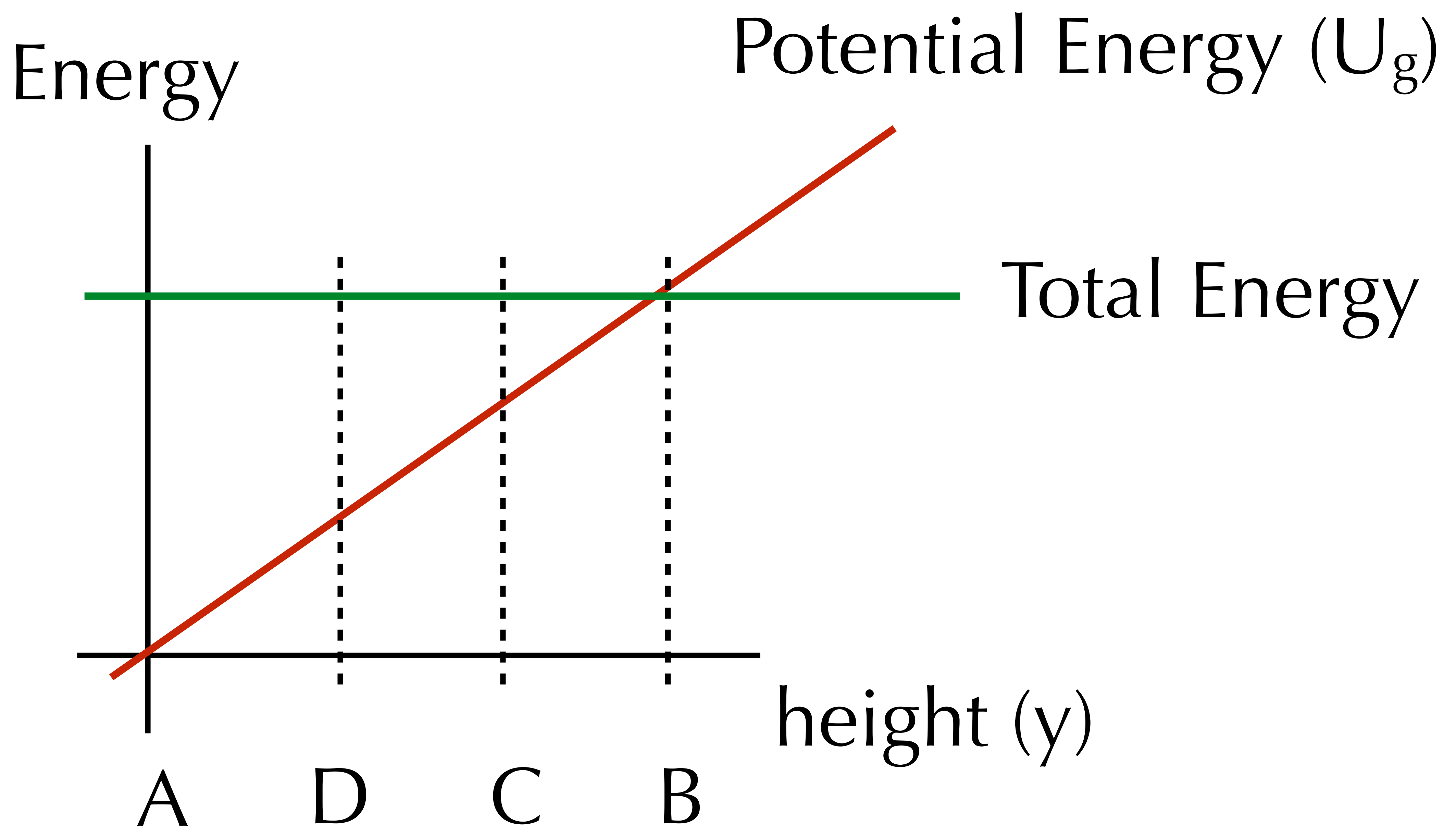
Where is the turning point of the motion?



$$U_g = mgy$$

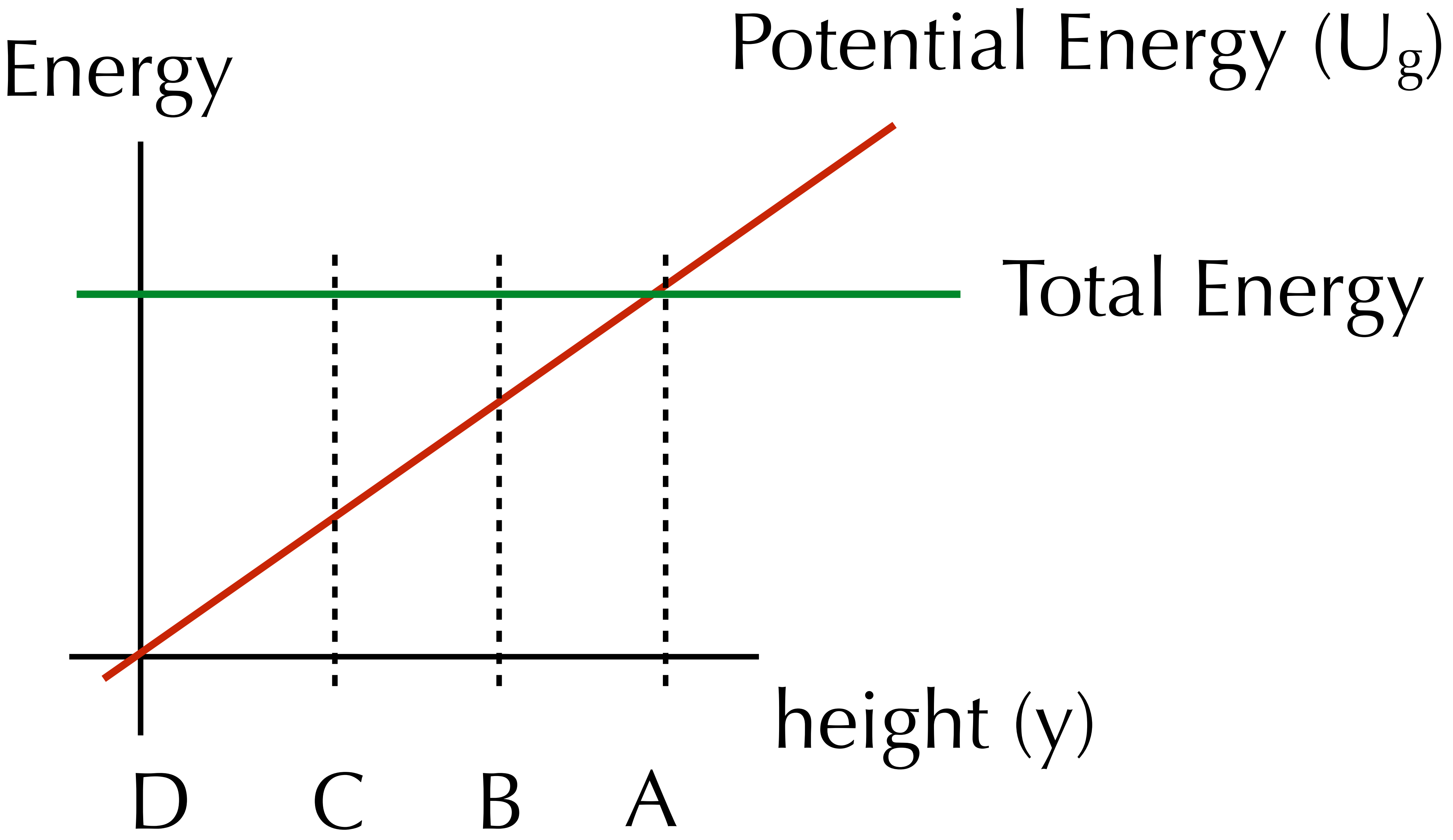
Energy diagram for ball thrown upward

Where does the object have the most potential energy?



Energy diagram for ball thrown upward

Where does the object have the most kinetic energy?

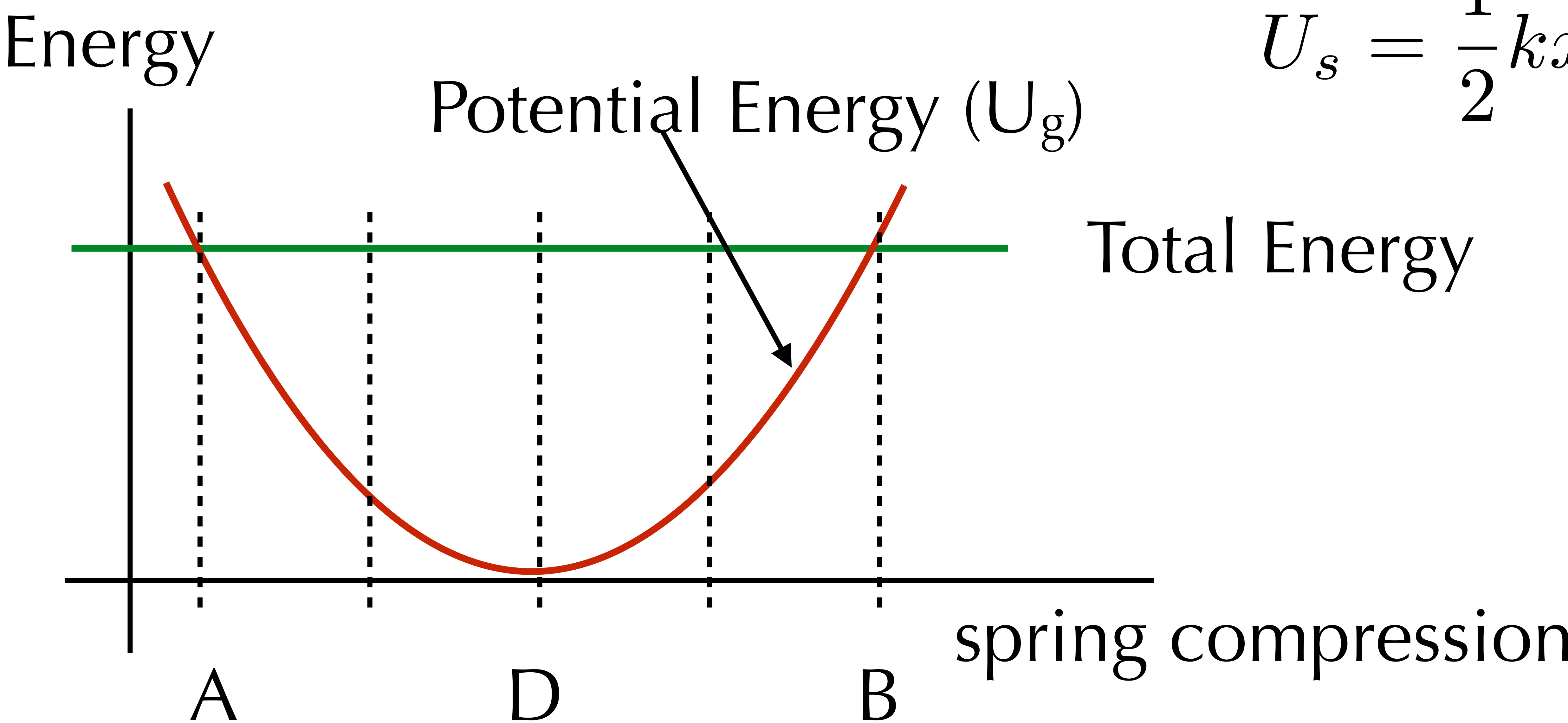


Energy diagram for mass on a spring

Question #38

Where is(are) the turning points of the motion?

$$U_s = \frac{1}{2}kx^2$$

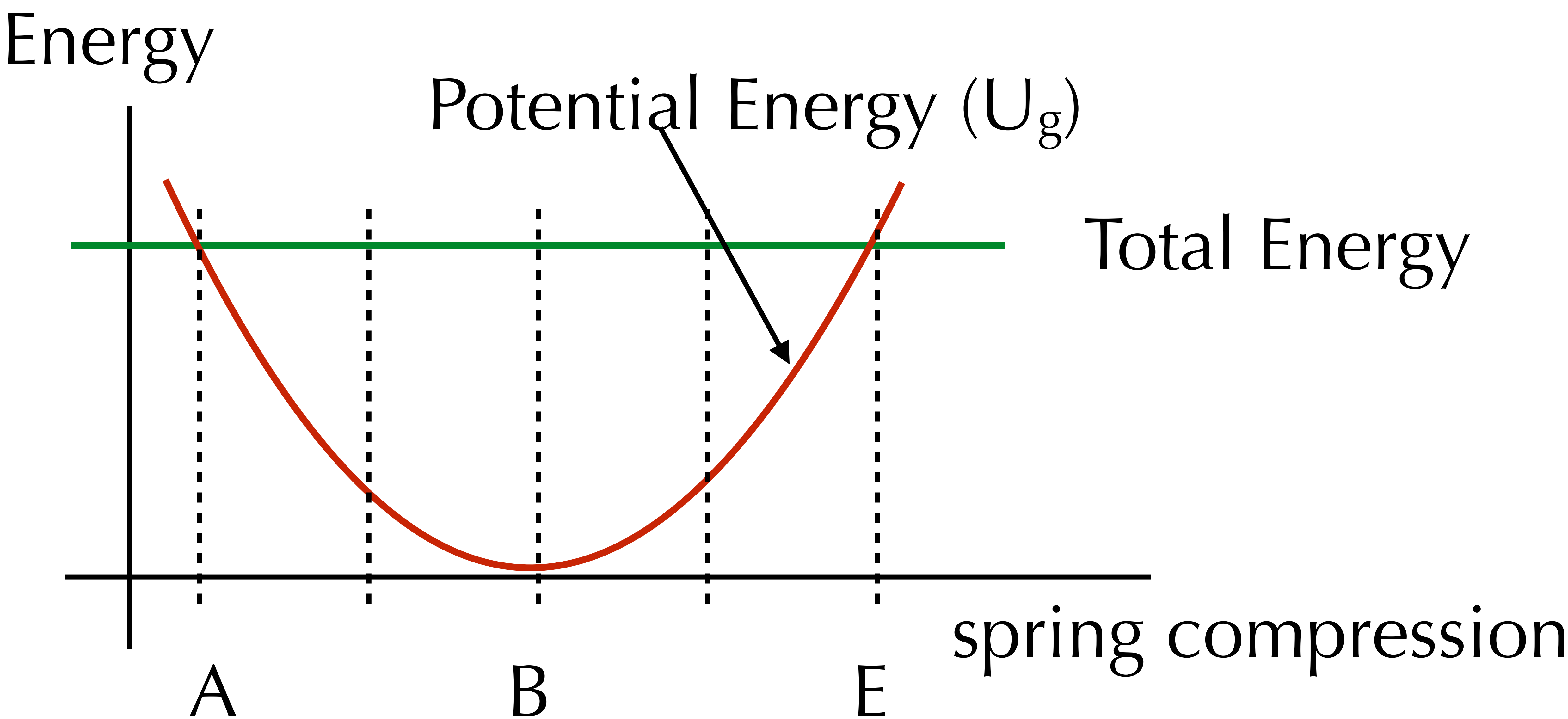


C. A and B are both turning points

E. All three are turning points.

Energy diagram for mass on a spring

Where does the object have the most potential energy?

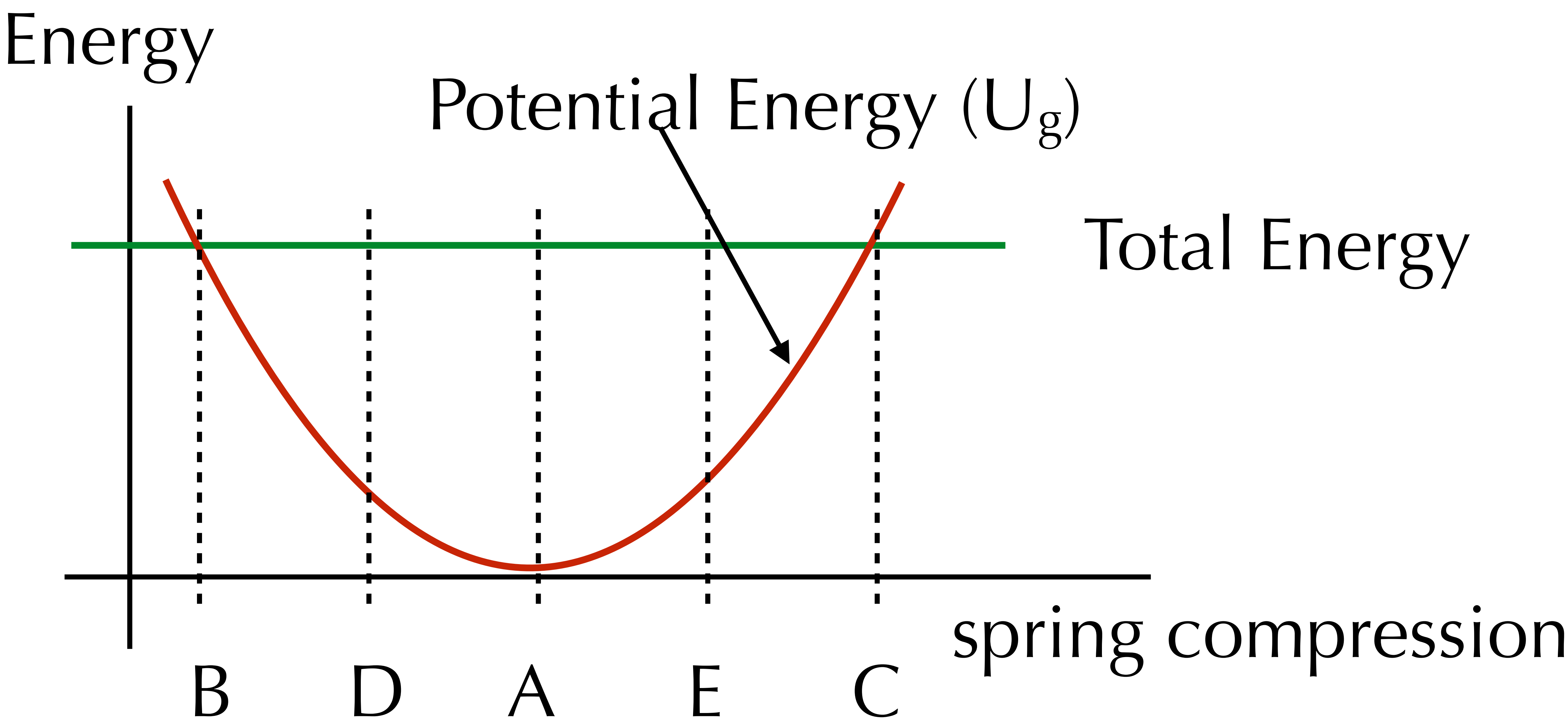


C. At points A and E

D. At points A and C

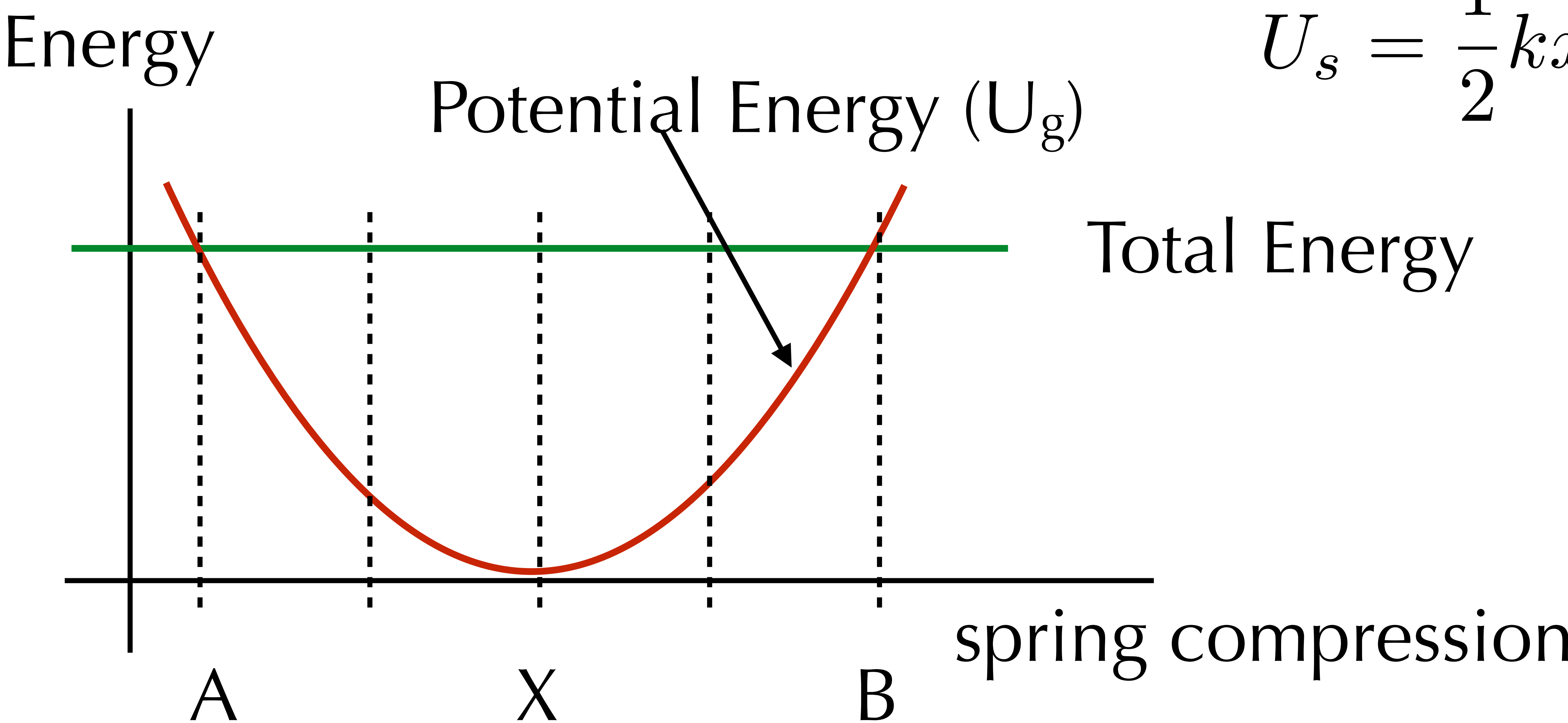
Energy diagram for mass on a spring

Where does the object have the most kinetic energy?



Where is the force of the spring on the object negative (left pointing)?

$$U_s = \frac{1}{2}kx^2$$



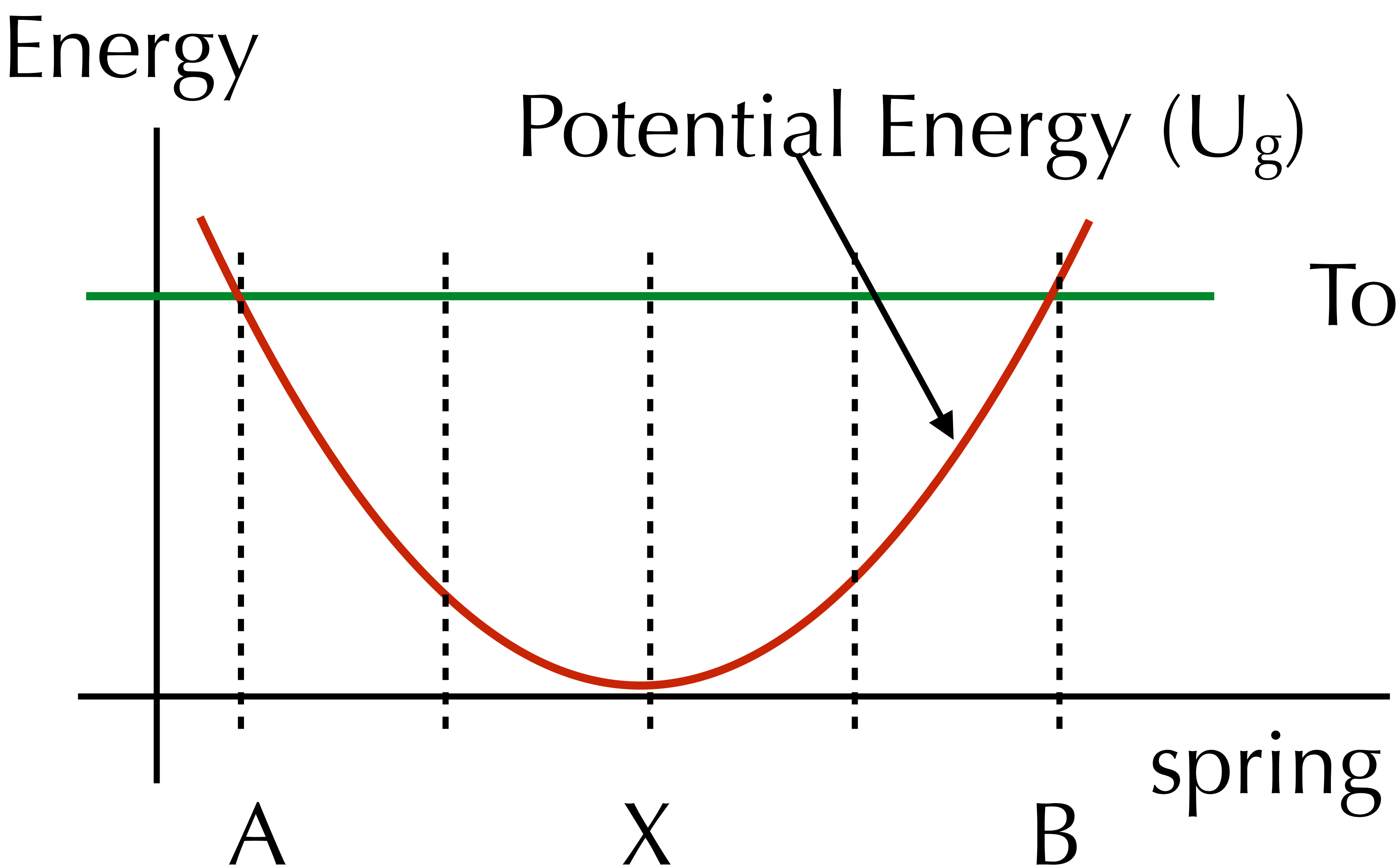
D) anywhere to the **left** of point X.

E) anywhere to the **right** of point X

Question #39

Where is the force of the spring on the object negative (left pointing)?

$$U_s = \frac{1}{2}kx^2$$



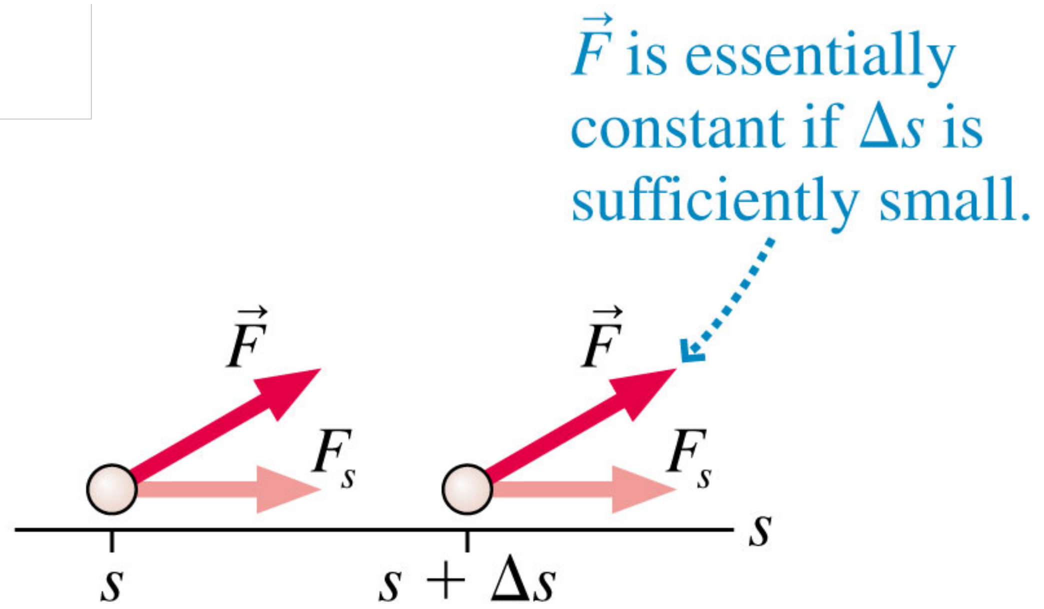
D) anywhere to the **left** of point X.

E) anywhere to the **right** of point X

$$F = -\frac{dU}{ds}$$

Finding Force from Potential Energy

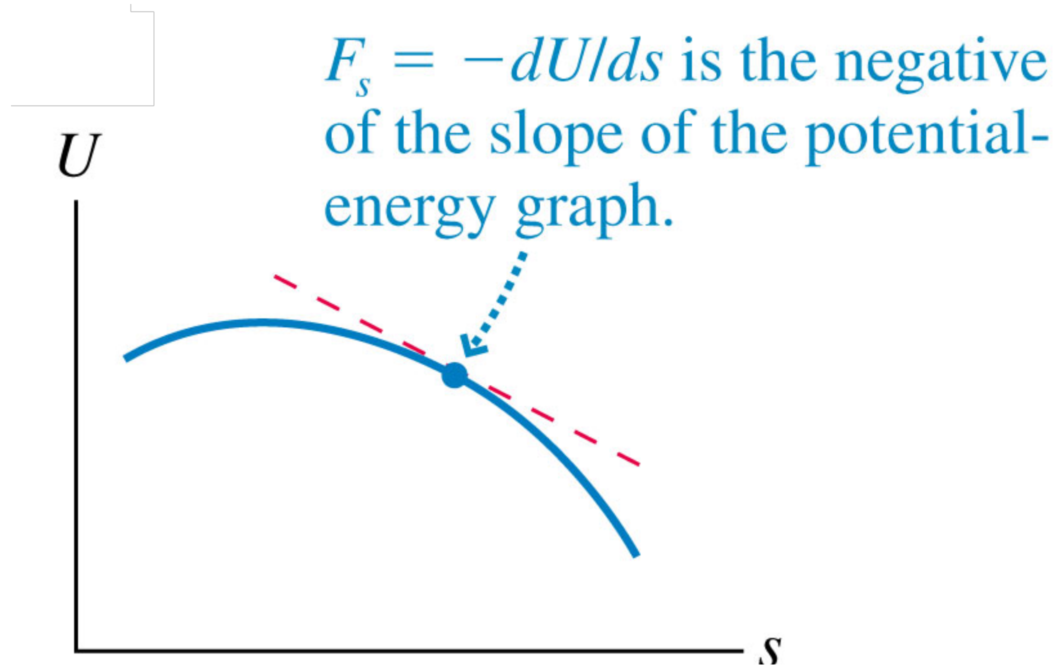
$$W(s \rightarrow s + \Delta s) = F_s \Delta s$$



$$\Delta U = -W = -F_s \Delta s$$

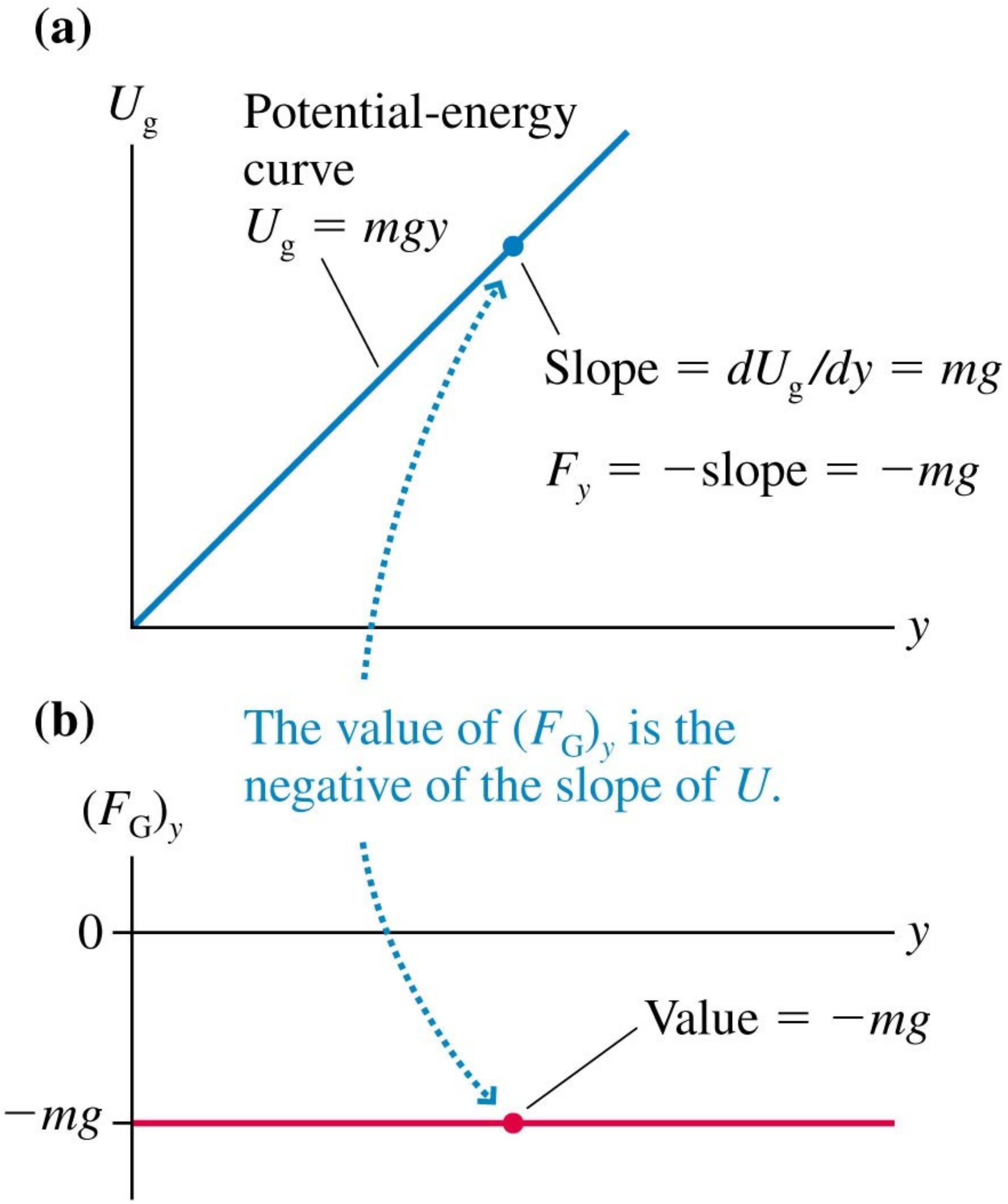
$$F_s = -\frac{\Delta U}{\Delta s}$$

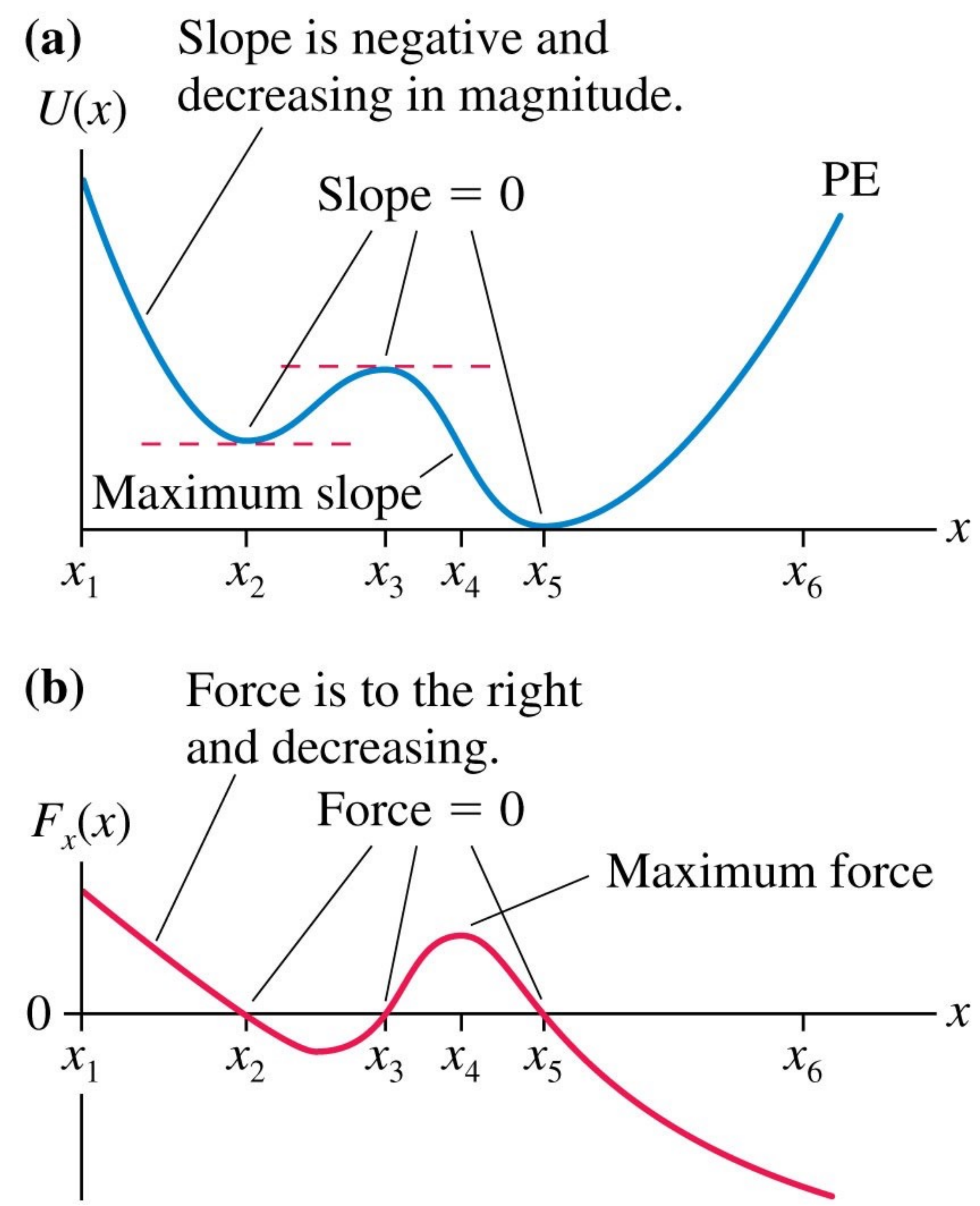
$$F_s = \lim_{\Delta s \to 0}\left(-\frac{\Delta U}{\Delta s}\right) = -\frac{dU}{ds}$$



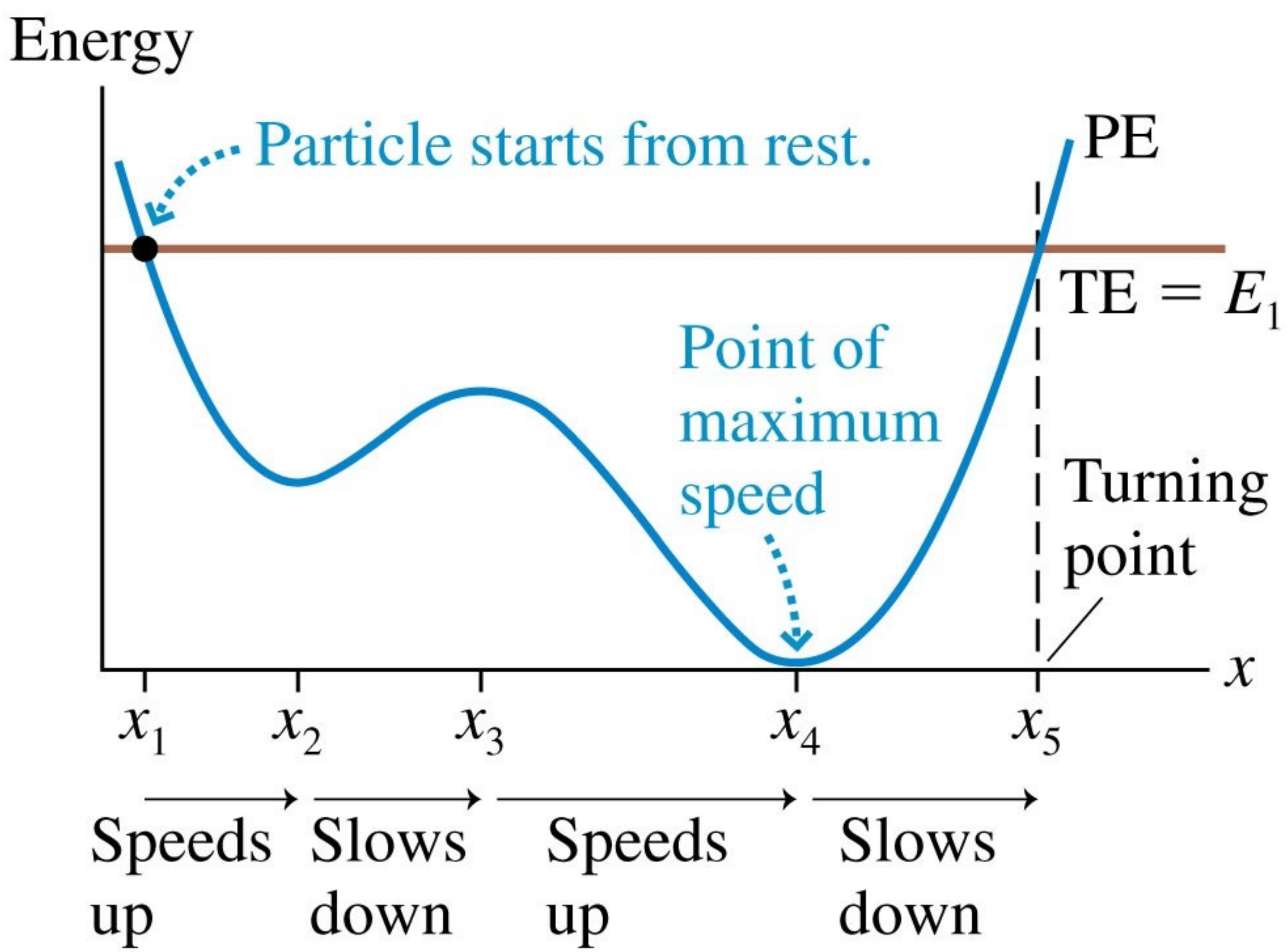
$$U = -\int_{s_1}^{s_2} F_s ds$$

Finding Force from Potential Energy





Energy Diagrams



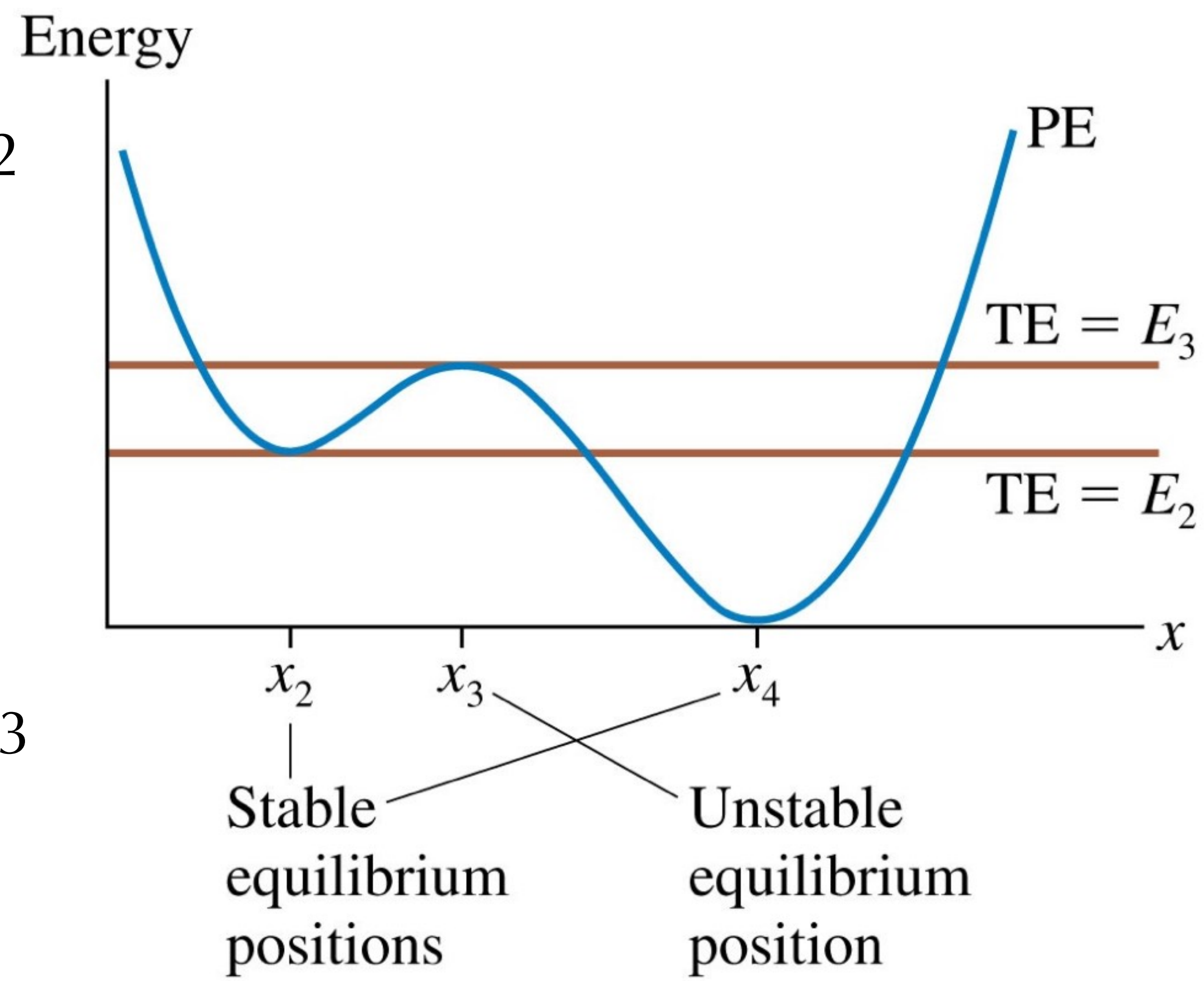
Equilibrium positions: Stable vs. Unstable

$\boxed{\text{Stable Equilibrium}}$

Consider particle with energy E_2

$\boxed{\text{Unstable Equilibrium}}$

Consider particle with energy E_3

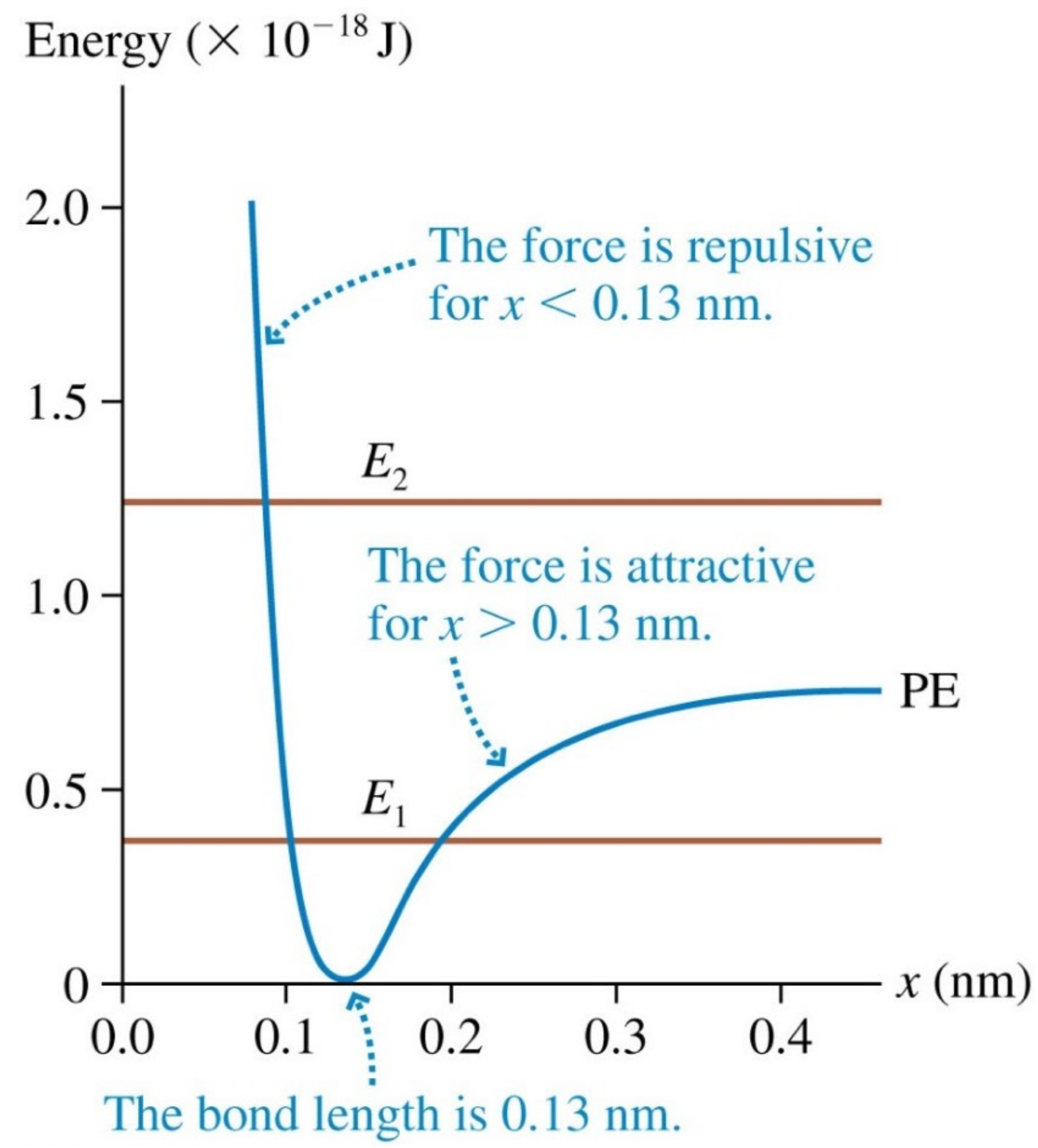


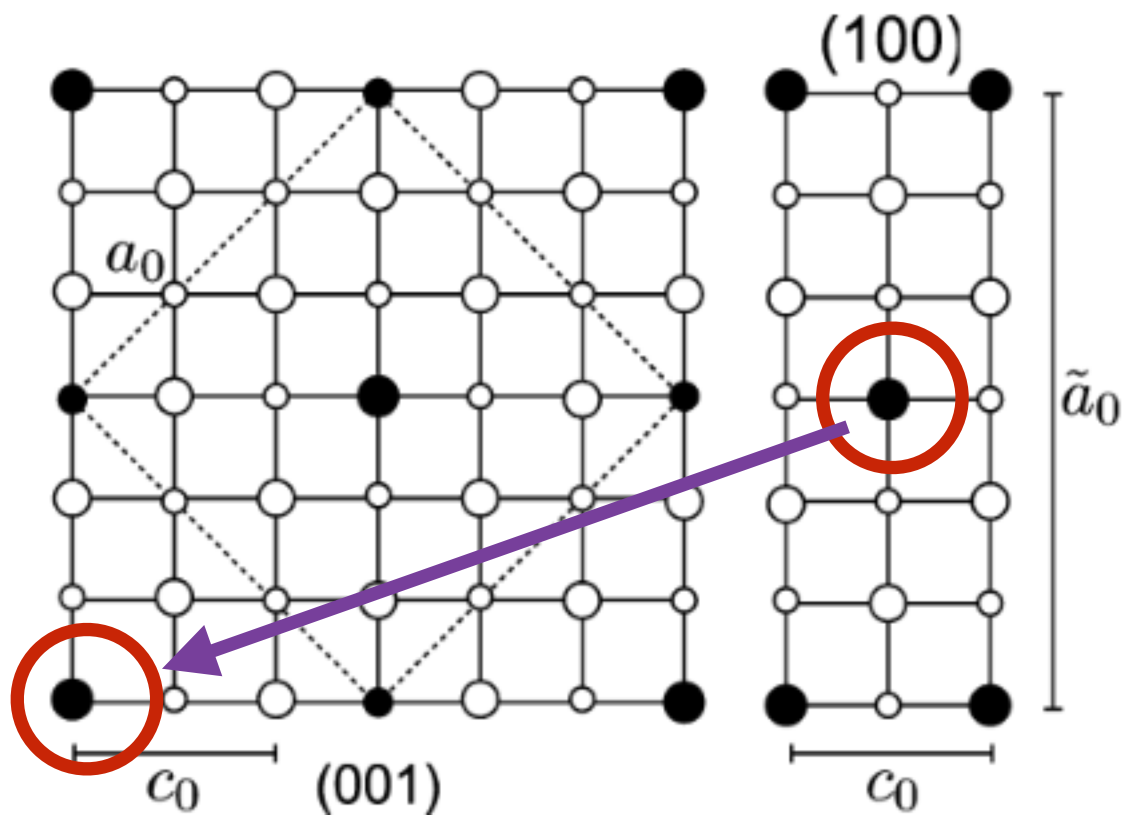
Molecular Bonds

Potential Energy curve for Hydrogen Chloride

When the total energy is E_1, the molecule oscillates and is stable

When the total energy is E_2, the bond is broken and the atoms come apart.





(100)
a_0
$\tilde{a}_0$
c_0
(001)
c_0