

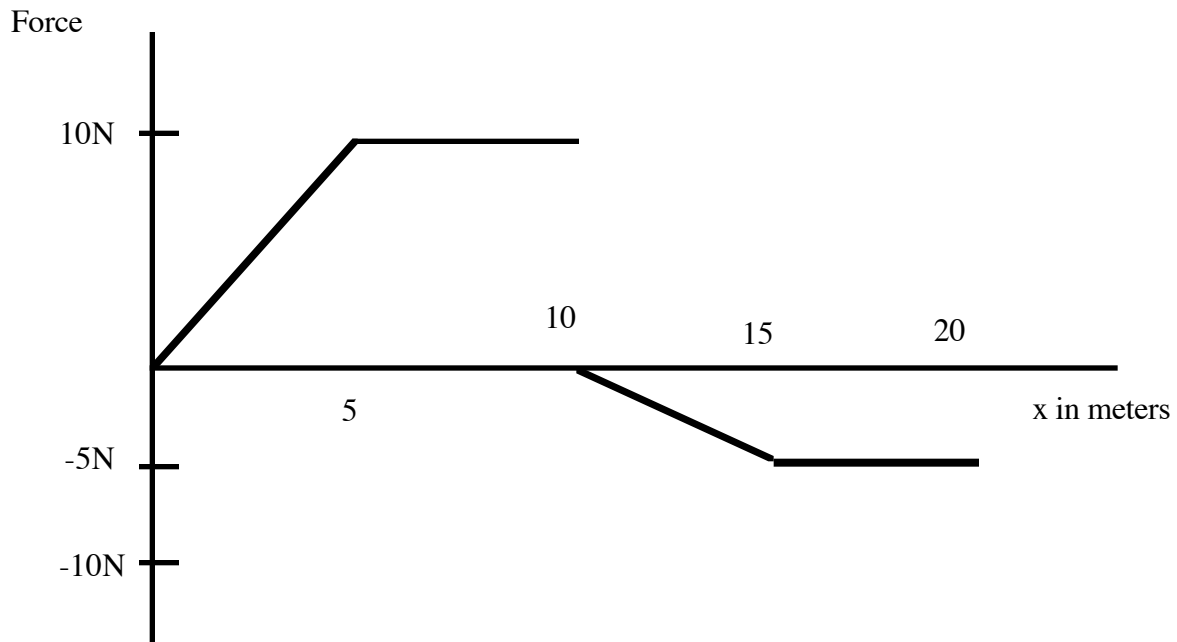


8. A 20,000 kg mass has a velocity of  $\vec{v}_1 = 100\hat{i} \text{ m/s}$ . It collides and sticks to a mass of 10,000 kg that was initially at rest. What is the final velocity of the composite system?

9. Is it possible to write a potential energy for the forces associated with breaking a glass window? Why or why not?

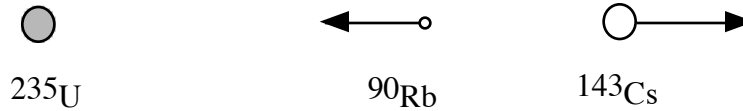
**Problems. Please work two (2) of the three problems.**

1. A 500 kg mass initially at rest is subjected to a force as shown below.



- What is the work done on the mass when it moves from  $x=0$  to  $x=5$ ?
- What is the work done on the mass as it moves from  $x=5$  to  $x=10$ ?
- What is the velocity of the mass at  $x=10$  m?
- What work was done on the mass in moving from  $x=10$  to  $x=20$ ?
- What total work was done on the mass in moving from  $x=0$  to  $x=20$  and what is the mass' kinetic energy and velocity at  $x=20$ m?

2. A particular isotope of Uranium known as  $^{235}\text{U}$  will spontaneously fission (or split) into two nuclei,  $^{90}\text{Rb}$  and  $^{143}\text{Cs}$ . Consider a Uranium nucleus at rest before the decay. After the decay, the  $^{90}\text{Rb}$  has a velocity to the left  $\vec{v}'_{\text{Rb}} = -1.0 \times 10^8 \text{ m/s} \hat{i}$ . Take the masses to be:  $m_{\text{U}} = 3.92 \times 10^{-25} \text{ kg}$ ,  $m_{\text{Rb}} = 1.50 \times 10^{-25} \text{ kg}$ , and  $m_{\text{Cs}} = 2.39 \times 10^{-25} \text{ kg}$ .



- What are the initial momentum and kinetic energy of the Cs.
- What is the final momentum of the Rb-Cs system? What is final velocity of the Cs?
- What is the final kinetic energy of the Rb-Cs system? What was the change in the kinetic energy in this decay?

Note: We have ignored neutrons produced in this process to make the problem simpler. The energy for this decay comes from the difference in masses between the initial and final states. Even after including the neutrons, the mass of the initial U is slightly larger than the mass of the products of the fission. The mass that “disappears” turns into kinetic energy via Einstein’s famous formula  $E = mc^2$ .

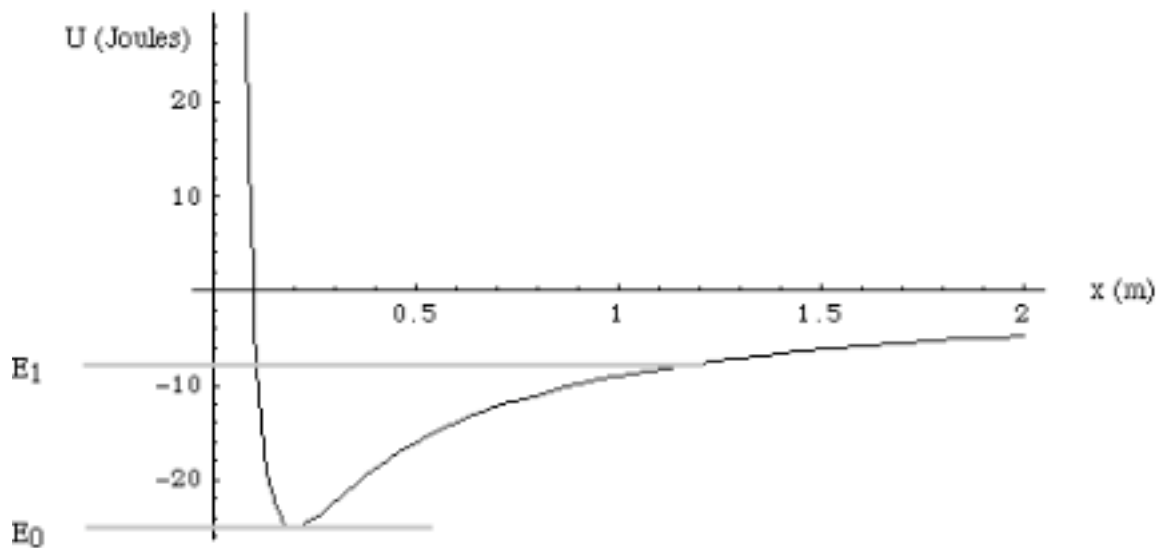
3. Consider the potential curve below.

a) Describe the motion that a mass with energy  $E_0$  can undergo. Note be sure to describe all of the motions and turning points. You may estimate their numerical values from the graph

b) Describe the motion that a mass with energy  $E_1$  can undergo. Note be sure to describe all of the motions and turning points. Estimate numerical values from the graph

c) In what regions of  $x$  is the force directed to the right? In what regions of  $x$  is the force directed to the left. How do you know this?

d) Identify all of the places where the is the force zero? How do you know this?



## Useful Formulas

### Conversions:

$$1 \text{ mile} = 1.6 \text{ km}$$

$$1 \text{ inch} = 2.54 \text{ cm}$$

$$1 \text{ mile} = 5280 \text{ ft.}$$

$$1 \text{ foot} = 0.3048 \text{ m}$$

### Constants:

$$g = 9.8 \text{ m/s}^2 = 32 \text{ ft/s}^2$$

### Misc. Equations:

$$\text{Volume of a sphere} = (4/3) \pi r^3$$

$$\text{Volume of a cylinder} = \pi r^2 L$$

$$\text{Area of a circle} = \pi r^2$$

$$\text{Volume of a rect. obj.} = L \times W \times D$$

$$\text{Area of a triangle} = (1/2) * \text{base} * \text{height}$$

$$\sin \theta = \text{opp/hyp}$$

$$\cos \theta = \text{adj/hyp}$$

$$\tan \theta = \text{opp/adj}$$

### Derivative of a Polynomial.

*Example:*

$$\frac{d}{dx}(ax^n) = nax^{n-1}$$

$$\frac{d}{dx}(ax^3) = 3ax^2$$

### Integral of a polynomial.

*Example:*

$$\int ax^n dx = \frac{ax^{n+1}}{n+1}$$

$$\int bx^3 dx = \frac{bx^4}{4}$$