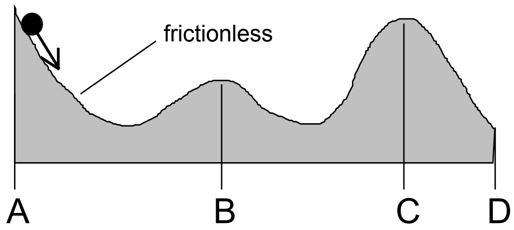
LECTURE #21 – SUMMARY

Section III.8 Force and Potential Energy
Potential Energy Curves



How fast must a train be coasting at A to reach D?
The normal force and gravity act on the train.
$\vec{N} \perp d\vec{r}$ so only gravity (conservative) does work.
Apply conservation of E_m.

To get to D, the train has to get over the top at C. Say that the train JUST gets over C, i.e., K_C=0. So the energy at C will be all gravitational potential energy.

$$E_C = U_{reference} + mgh_C$$

Therefore, to get to D, the actual energy of the system must be larger than this.

$$E_A = \tfrac{1}{2}mv_A^2 + U_{reference} + mgh_A$$

So: $E_A \geq E_C$, $\tfrac{1}{2}mv_A^2 + U_{reference} + mgh_A \geq U_{reference} + mgh_C$, $v_A \geq \sqrt{2g(h_C - h_A)}$

If $\tfrac{1}{2}mv_A^2$ > ΔU between A and C, then there is enough energy to get over C.

If v_A is not greater than $\sqrt{2g(h_C - h_A)}$, then the energy of the system will be insufficient to get the train over the hill at C

→ This hill acts as a potential barrier preventing the train from reaching D.

$\Delta U = mg\Delta y$, so the shape of the roller coaster is the same as the shape of the gravitational potential energy → potential energy curve ≡ plot of U vs. position

Force and Potential Energy

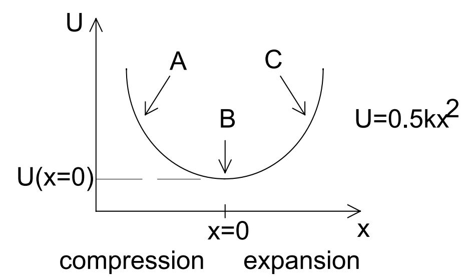
For 1-D nonconstant force: $U(x) = U(x_s) - \int_{x_s}^{x} F_x^c dx$. Differentiate: $\boxed{\dfrac{dU(x)}{dx} = -F_x^c}$

Potential energy curve for a spring: $F = F_o^s(x) = -kx$

(A) compression: $x < 0$, $\frac{dU}{dx} < 0$, $F > 0$

(B) equilibrium: $x = 0$, $\frac{dU}{dx} = 0$, $F = 0$

(C) stretching: $x > 0$, $\frac{dU}{dx} > 0$, $F < 0$



When nonconservative forces are acting:

$$W^{C}_{net}\, W^{C}_{net} + W^{NC}_{net} = K_f - K_i \qquad \text{(generally true)}$$

$$W^{NC}_{net} = K_f - K_i - W^{C}_{net} = K_f - K_i + \Delta U_{i\to f} = E^f_m - E^i_m \qquad \to \qquad \boxed{W^{NC}_{net} = \Delta E_m}$$

Note: The change in U is associated with conservative forces only.
When nonconservative forces are acting, $\Delta E_m \neq 0$. The change in mechanical energy = net work done by the nonconservative forces (i.e., dissipation).
Can $\Delta E_m = 0$ when nonconservative forces are present? Yes when $\vec{F}^{NC}_{net} \bullet d\vec{r} = 0$.