2020/10/09 - PHYS 2211 M

Energy Graphs

$$\Delta E_{system} = W_{surroundings}$$

$$\Delta U \equiv - W_{internal}$$

$$K = \frac{1}{2}mv^2; \quad \Delta K = \frac{1}{2}m(v_f^2 - v_i^2)$$

@surface of Earth $\Rightarrow$ $U_g = mgh; \quad \Delta U_g = mg\Delta h$

$$U_g = \frac{-GMm}{r}$$

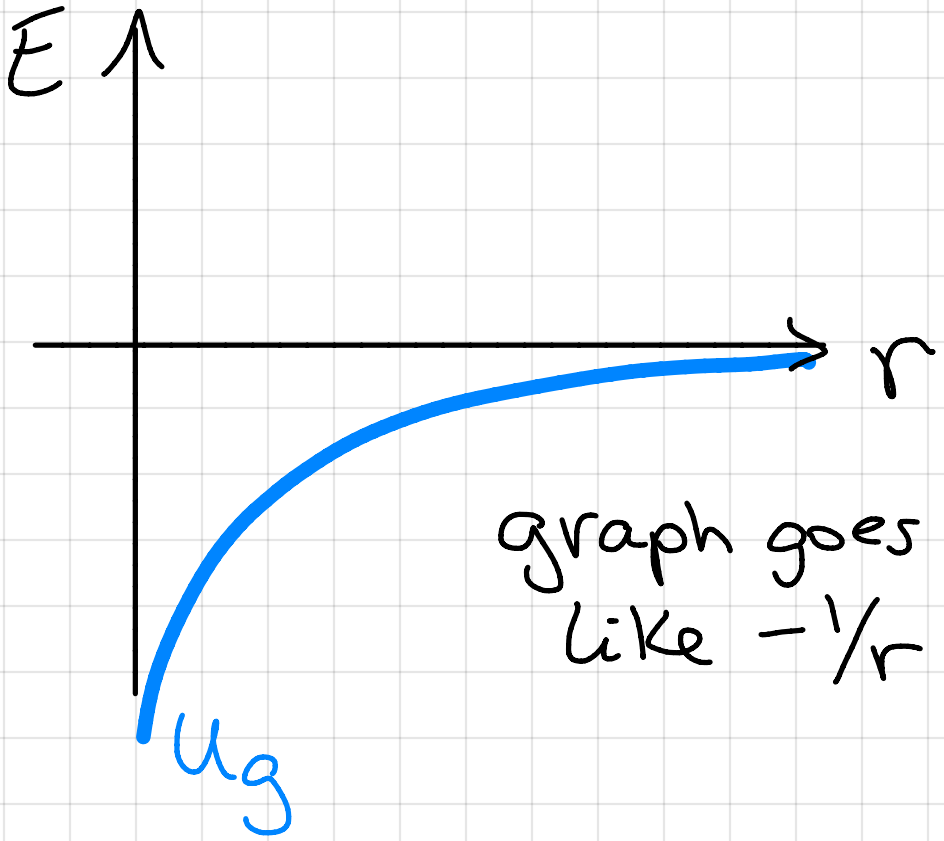
$$\Delta U_g = -GMm\left(\frac{1}{r_f} - \frac{1}{r_i}\right)$$

$$U_e = \frac{kq_1q_2}{r}$$

$$\Delta U_e = kq_1q_2\left(\frac{1}{r_f} - \frac{1}{r_i}\right)$$

Gravitational Potential Energy

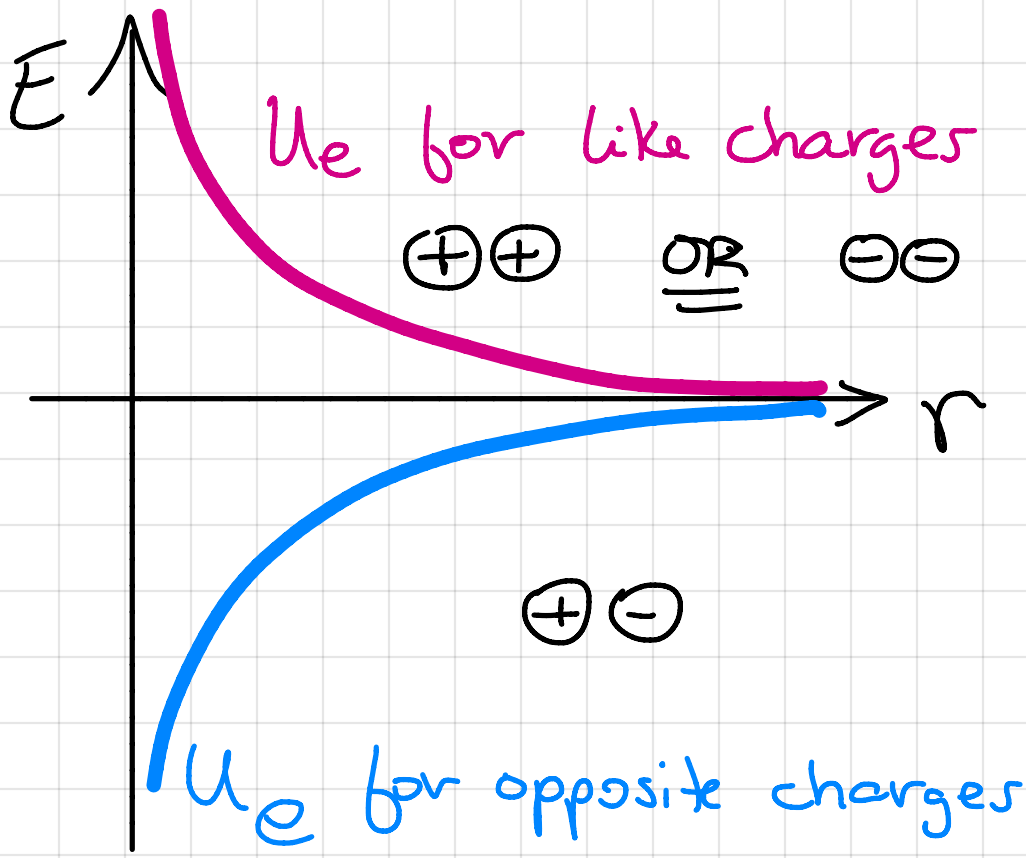
$$U_g = \frac{-GMm}{r}$$



* Always negative (attractive)
* $U_g \to 0$ as $r \to \infty$
* As $r \to 0$, U_g gets more and more and more negative

Electric Potential Energy

$$U_e = \frac{k q_1 q_2}{r}$$



* Repulsive (positive) for like charges (+ +, or − −)
* Attractive (negative) for opposite charges (+ −, or − +) → like U_g
* As $r \to \infty$, $U_e \to 0$ regardless

Bound and Unbound Systems

* **Bound**

$E = K + U < 0$

total energy is negative

restricted range

* **Unbound**

$E = K + U > 0$

total energy is positive

$K \neq 0$ as $r \to \infty$

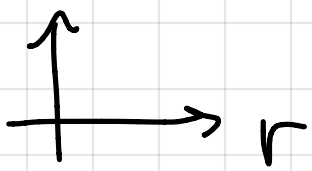
* **At escape speed**

$E = K + U = 0$

$K = 0$ when $r \to \infty$

How to Draw Energy Graphs

1. Identify if the potential energy is attractive (U_g, U_e for opposite charges) or repulsive (U_e for like charges), then draw it in the diagram

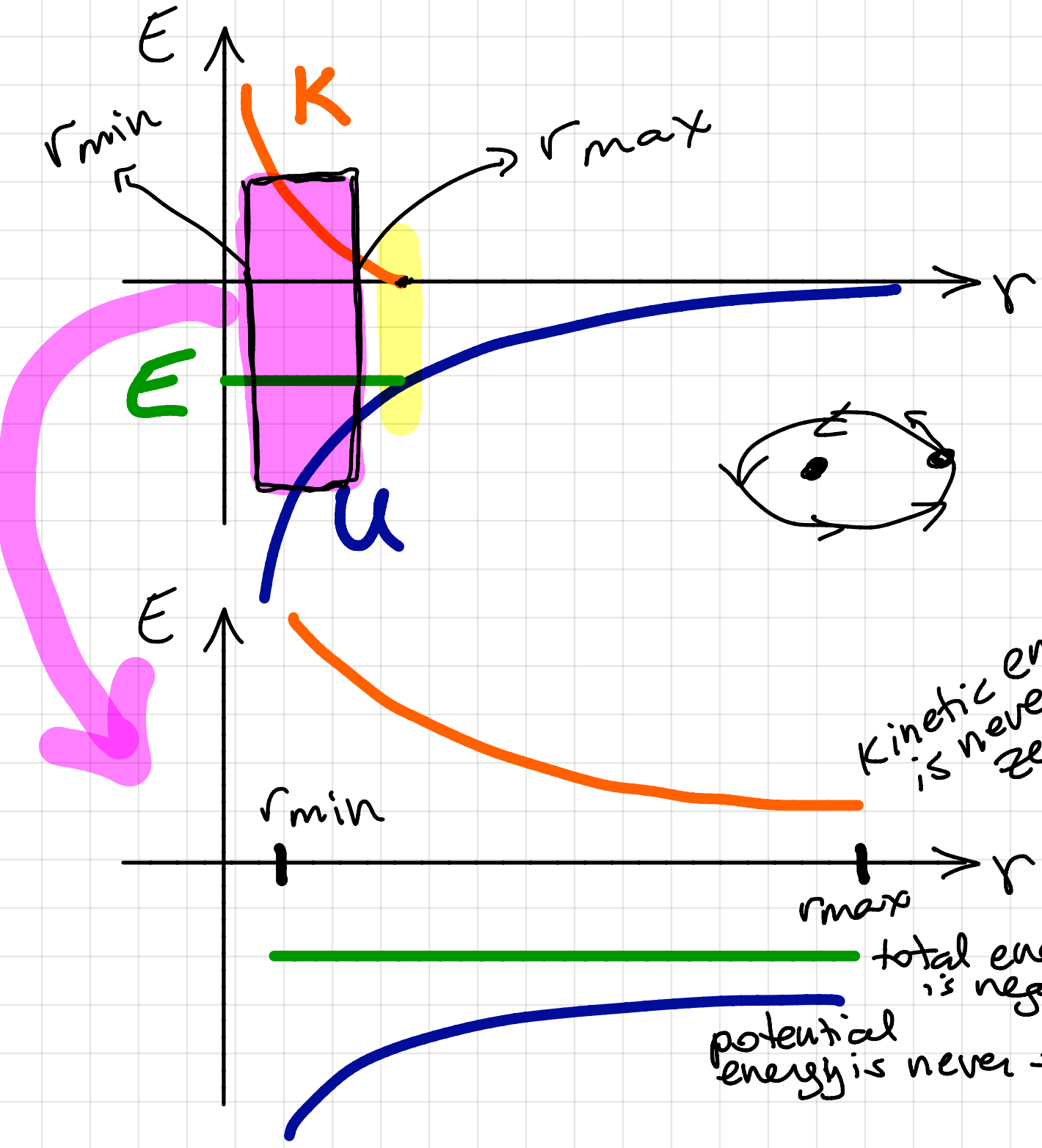


2. Determine if the system is bound ($E<0$), unbound ($E>0$), or at escape speed ($E=0$), then draw the total energy as a horizontal line (b/c isolated system)

3. Draw the kinetic energy, and remember that it's always positive

Graph #1: Bound System

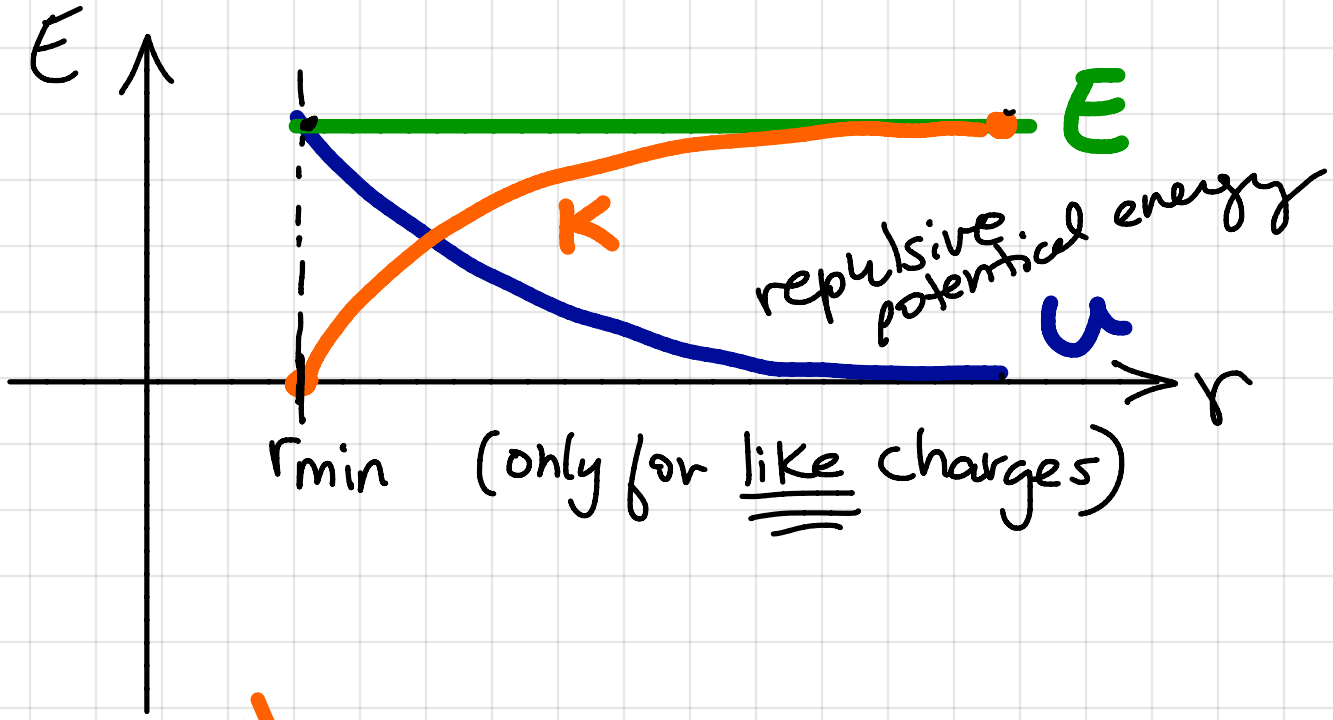
K
U
K+U

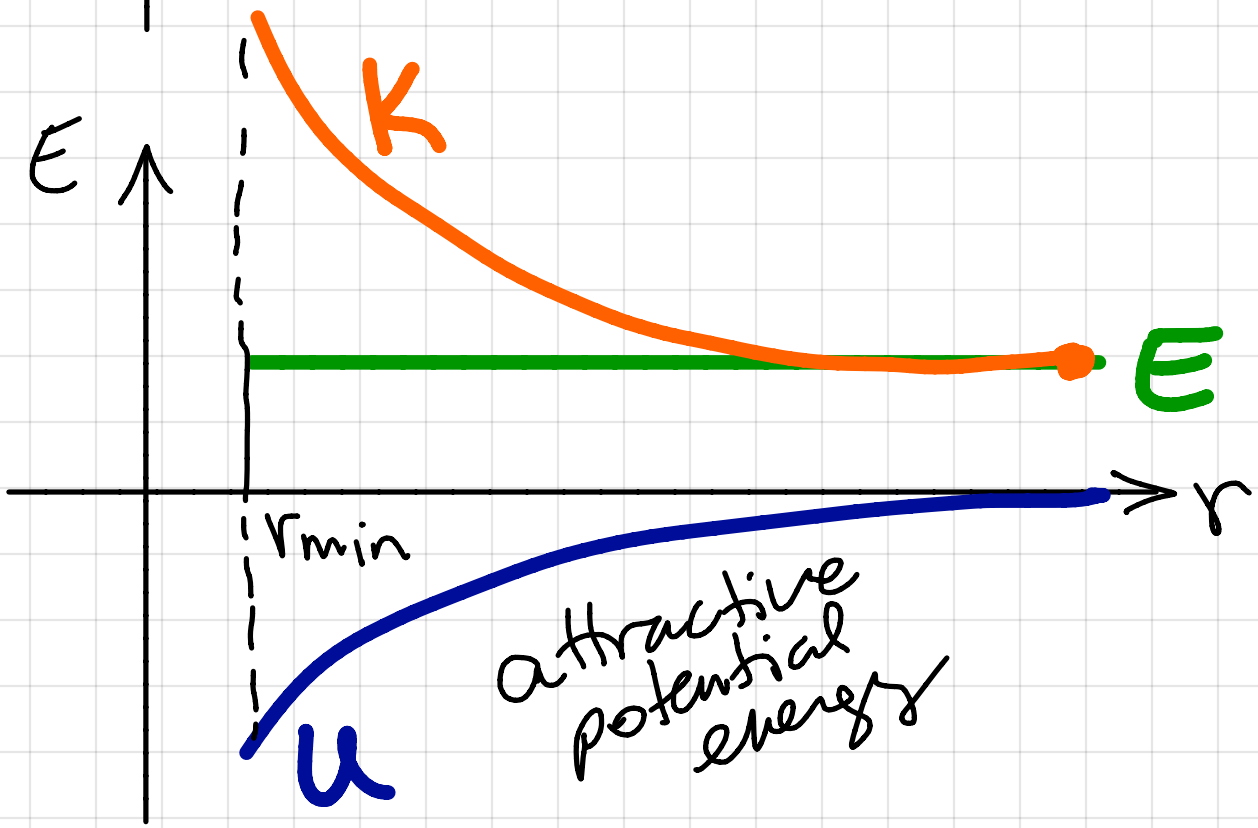


Examples: ✓ stuff orbiting other stuff
✓ opposite charges moving towards each other

Graph #2: Unbound system

K
U
K+U





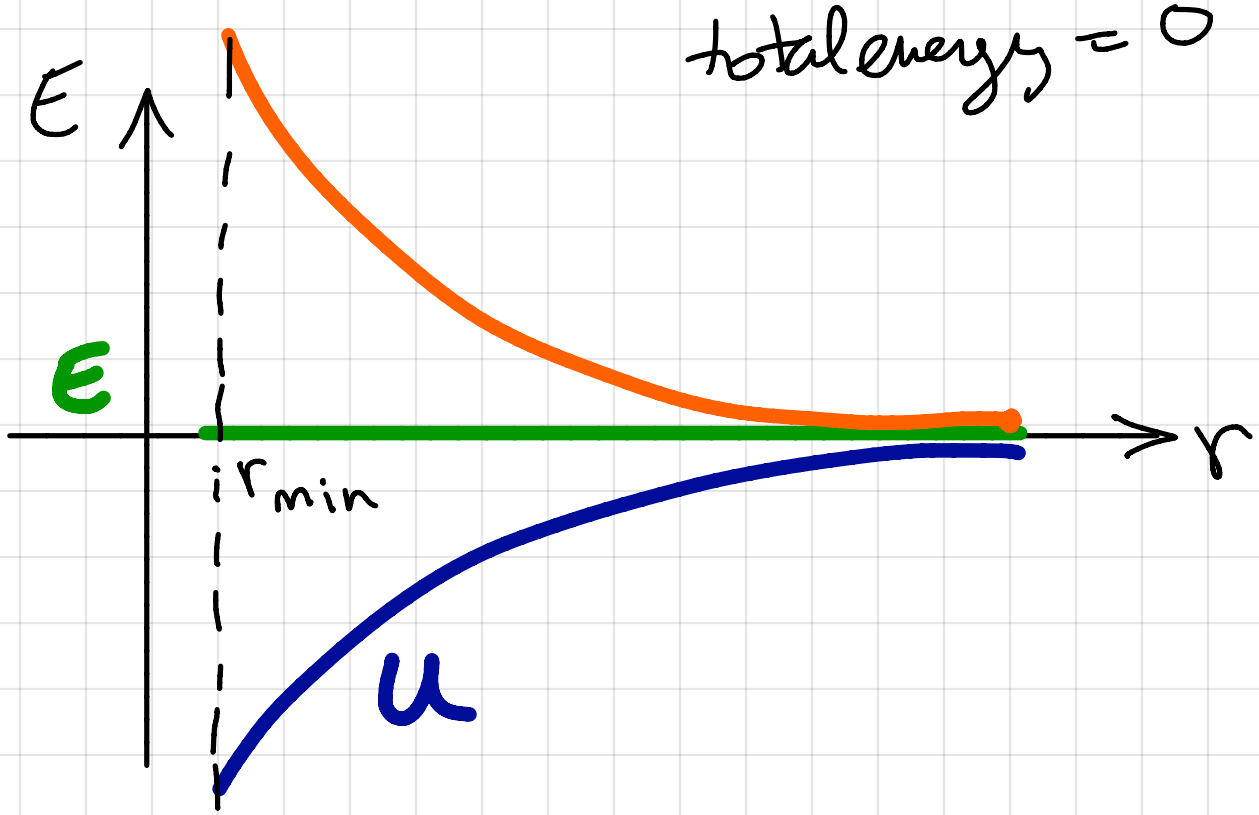
Examples:
- ✓ things that repel each other
- ✓ open orbits where the smaller thing has $V \neq 0$ @ $r \to \infty$

K
U
K+U

Graph #3: At escape speed

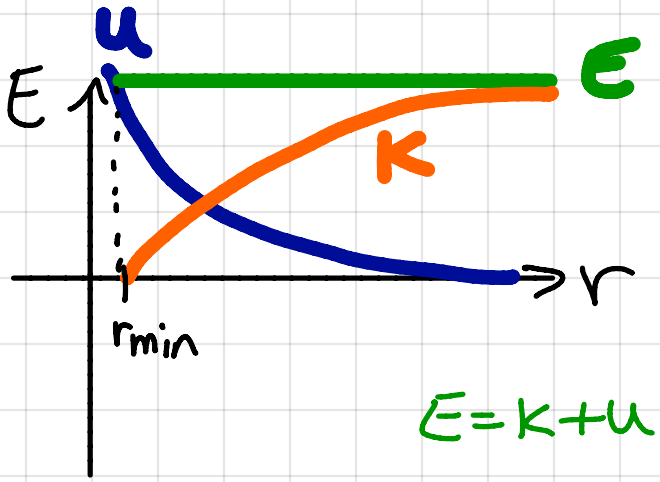
↓

total energy = 0

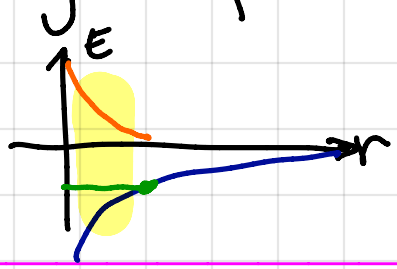


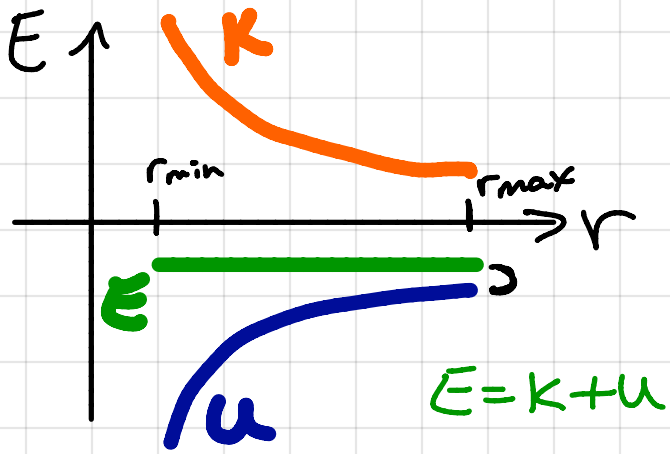
✓ $V = 0$ @ $r \to \infty$

Two electrons are held close together then are let go.



Halley's Comet orbits the sun once every 76 years.

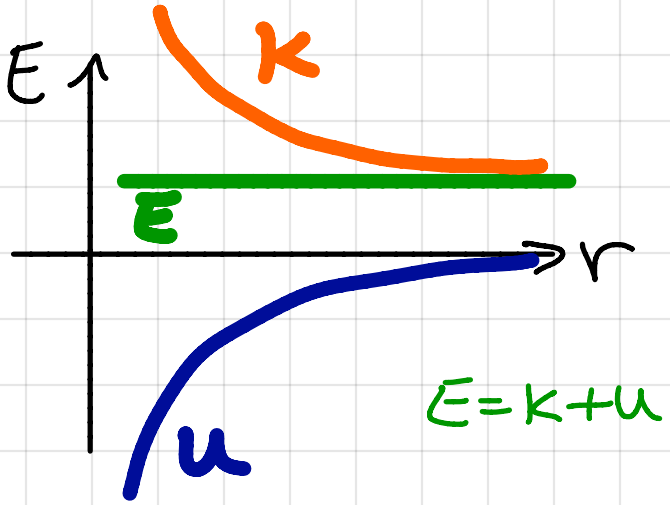




Voyager 1 is very very far away from the Sun, and traveling at 17 km/s.

$r \to \infty$

$K \neq 0$ @ $r \to \infty$



A spaceship leaves Earth's surface with initial speed $\sqrt{\frac{2GM_E}{R_E}}$

@ $r \to \infty$

$K = 0 \Rightarrow V = 0$