Electromagnetic Rail Gun (Fig. 27-54, p. 1060)

Bar of mass \( m \) and length \( L \)

Sliders over horizontal rails connected to a Voltage source.

Constant \( I \) in rails + bar.

Constant vertical \( \overrightarrow{B} \).

(a) Find mag. + direction of net force on the bar. Ignore all reality! (Friction, air resistance + electrical resistance, etc.)

This is covered in Section 28-7, mag. force on a current carrying conductor. (Eqs. 27-17 to 19.) Check out Fig. 28-21 for force on a wire segment.

\[
F = I LB
\]

\( \xi L + B \sin \phi = \sin 90^\circ = 1 \)

(b) Rail gun into orbit!

How long on Earth? \( \text{Earth} \), \( V_{rel} = 11.2 \text{km/s} \)

\( \beta = 0.505 \)

\( m = 25 \text{ kg} \) (55 lbs)

Hint: given by us: \( \text{Use} \)

\[
I = 2.0 \times 10^3 A \quad L = 50 \text{ cm} = 0.50 \text{ m}
\]

\[ \text{kinetic energy relation from dynamics} \]

\[ F = ma = I LB \]

Plus distance, acceleration and velocity.

\[ v^2 = v_0^2 + 2a(x - x_0) \]

Well if we start at rest and begin our back of rail gun then \( v_0 = 0 \text{ m/s} \) and \( x_0 = 0 \text{ m} \) and \( x = d \) to travel along rail and \( a \) in the acceleration we are looking for. So,

\[ v^2 = 2ad \quad \Rightarrow \quad d = \frac{v^2}{2a} \quad \text{or} \quad a = \frac{v^2}{2d} \]
\[ ma = JLB \]
\[ a = \frac{JLB}{m} = \frac{V^2}{2d} \]

**Solve for \( d \):**
\[ d = \frac{V^2 m}{2JLB} \]

\[ d = \frac{(11.2 \times 10^3 \text{ m/s})^2 (25 \text{ kg})}{2(2 \times 10^3 \text{ A}^2) (0.50 \text{ m}) (0.50 \text{ T})} \]
\[ = \frac{3.14 \times 10^9 \text{ m}}{100 \times 10^3} \]
\[ = 3.14 \times 10^6 \text{ m} = 3140 \text{ km} \]

\[ d = 3140 \text{ km} \quad \text{Yikes!} \]

\[ \text{Diameter of Earth} = 12,756 \text{ km} \]

**Not too practical here.**

I asked you to check this out on

Moon where \( V_{\text{esc}} \approx \frac{1}{4} \text{ Earth} \). This means

\[ d = \left( \frac{1}{4} V_{\text{esc}} \right)^2 \times \text{(same values)} \]
\[ = \frac{1}{16} \times (3140 \text{ km}) \]
\[ d = 196 \text{ km} \]

If current increased and \( B \) increased by factor \( 8 \)

in say, then the result is recovered by factor \( \frac{1}{10} \times \frac{1}{10} = \frac{1}{100} \) for a distance of \( 1.96 \text{ km} \) and we can

then it may be possible for Moon. This is an engineering

problem that is presently being worked on to

supply material in future for space station/colony

building by NASA.