

Must be interaction with one or more objects to cause a change in motion

Mass m and velocity both matter.

Momentum

$$\boxed{\vec{p} = \gamma m \vec{v}} = \gamma m \langle v_x, v_y, v_z \rangle$$

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

\vec{p} always same direction as \vec{v}

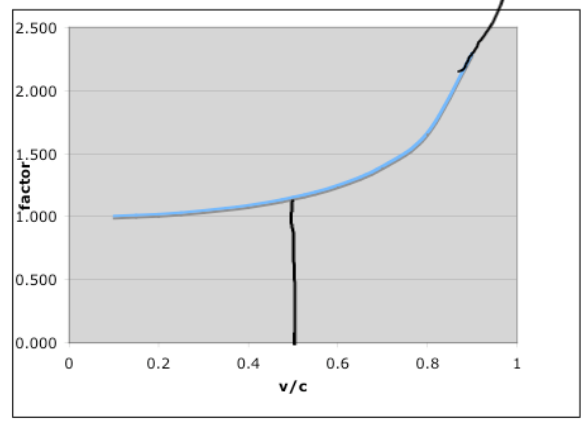
What is γ ?
 Table 1 use $v/c = 0.2$
 " 2 use 0.4
 ek.

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

for small velocities
 can approximate

$$\vec{p} \approx m\vec{v}$$

in x dir



Calc momentum of electron in TV set (25kV)
 moving at ~~in 3e7~~ $3e7$ m/s (0.1c)

$$\vec{p} = \gamma m \vec{v} \quad \gamma = 1.005$$
$$= \langle 2.74 \times 10^{-23}, 0, 0 \rangle \text{ kg m/s}$$

A: $|\vec{p}|$ of a fast runner

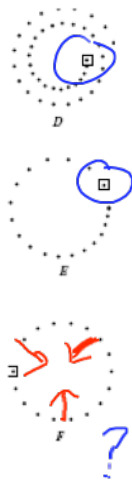
B: $|\vec{p}|$ of a baseball

C: $|\vec{p}|$ of fastest man-made object
Voyager 1

Momentum Principle

$$\vec{p}_f = \vec{p}_i + \underbrace{\vec{F}_{net} \Delta t}_{\text{impulse}}$$

$$\Delta \vec{p} = \vec{F}_{net} \Delta t$$



Newton's first law of motion

RQ 1.6 Moving objects left the traces labelled A-F. The dots were deposited at equal time intervals (for example, one dot each second). Which trajectories show evidence that the moving object was interacting with another object somewhere? In each case the object starts from the square.

