Q- What is the percentage change in momentum of a proton that accelerates from (a) 0.45c to 0.80c and (b) 0.80c to 0.98 c.

The relativistic momentum of a particle moving with velocity v is given by

$$p = \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}}$$

Here m_0 is the rest mass of the particle and c is speed of light

(a) The momentum of the proton at velocity 0.45c will be

$$p_1 = \frac{m_0 0.45c}{\sqrt{1-0.45^2}} = 0.504\, m_0 c$$

And the momentum of the proton at velocity 0.80c will be

$$p_2 = \frac{m_0 0.80c}{\sqrt{1-0.80^2}} = 1.333\, m_0 c$$

Thus the percent change is given by

$$\Delta P\ \% = \frac{p_2-p_1}{p_1} * 100 = \frac{1.333-0.504}{0.504} * 100 = 164\ \%$$

(b) The momentum of the proton at velocity 0.80c will be

$$p_2 = \frac{m_0 0.80c}{\sqrt{1-0.80^2}} = 1.333\, m_0 c$$

And the momentum of the proton at velocity 0.98c will be

$$p_3 = \frac{m_0 0.98\, c}{\sqrt{1-0.98^2}} = 4.925\, m_0 c$$

Thus the percent change is given by

$$\Delta P\ \% = \frac{p_3-p_2}{p_2} * 100 = \frac{4.925-1.333}{1.333} * 100 = 269\ \%$$