1. Zyklotron

(a)

$$F = qvB = q\omega rB = ma = m\frac{v^2}{r} = m\omega^2 r$$
$$\omega = \underline{\underline{\frac{qB}{m}}}$$
$$f = \underline{\underline{\frac{qB}{2\pi m}}}$$

(b)

$$v = \frac{qBr}{m}$$
$$K = \frac{mv^2}{2} = \underline{\underline{\frac{(qBr)^2}{2m}}}$$

(c)

$$r = \frac{mv}{qB}$$
$$v_n = v_{n-1} + \sqrt{\frac{8W_0}{m}} = n\sqrt{\frac{8W_0}{m}}$$
$$r_n = r_{n-1} + \frac{\sqrt{8W_0 m}}{qB} = \underline{\underline{n\frac{\sqrt{8m}}{qB}\sqrt{W_0}}}$$

(d) The Cyclotron is used to accelerate charged Particles to up to 50 MeV. At these energies relativistic effects come into play and disrupt the cyclotron. To reach higher energies a similar machine with an adjustable B-Field (the Synchrotron) can be used.

2. Geschwindigkeitsfilter

$$\vec{E} = \begin{pmatrix} 0 \\ 0 \\ E \end{pmatrix}; \quad \vec{B} = \begin{pmatrix} 0 \\ B \\ 0 \end{pmatrix}$$

(a) $\omega = \sqrt{\frac{mgl}{I}}$

3. Der magnetische Spiegel

$$v = \begin{pmatrix} v_x \\ v_y \\ v_z \end{pmatrix}$$

(a)

$$v = v_\perp + v_\parallel = \begin{pmatrix} v_x \\ v_y \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ v_z \end{pmatrix}$$

$$F_L = q v_\perp B = m \frac{v_\perp^2}{r} = F_Z$$

$$r_L = \underline{\underline{\frac{m v_\perp}{qB}}}$$

(b) $T = \frac{2\pi m}{qB}; \quad r = \frac{m v_\perp}{qB}$

$$E = E_z + E_\perp = \frac{m {v_\parallel}^2}{2} + \frac{m {v_\perp}^2}{2}$$

$$\vec{\mu} = I \vec{A} = \frac{q}{T} r^2 \pi \vec{n_a} = \frac{q}{\frac{2\pi m}{qB}} \left(\frac{m v_\perp}{qB}\right)^2 \pi \vec{n_a} = \frac{q^2 B}{2\pi m} \frac{m^2 {v_\perp}^2}{q^2 B^2} \pi = \frac{m {v_\perp}^2}{2} \frac{1}{B} =$$

$$= \underline{\underline{\frac{E_\perp}{B}}}$$

(c)

$$v_z(B) =$$