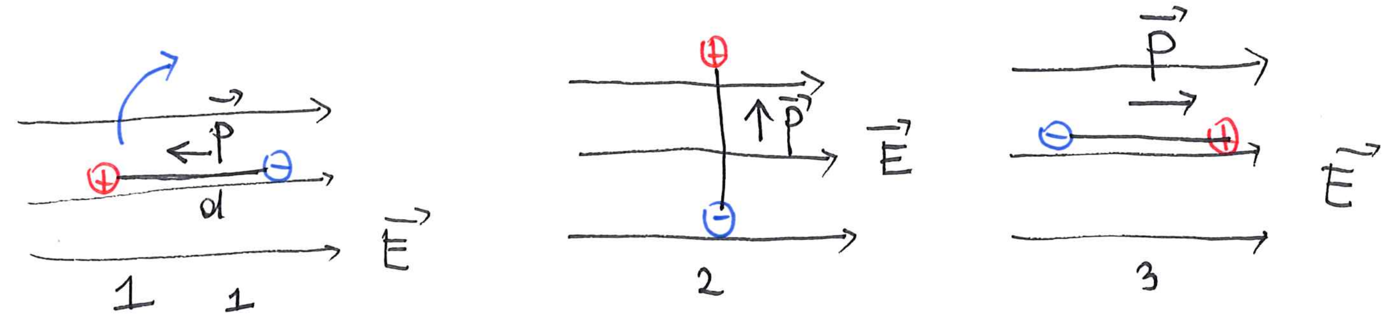
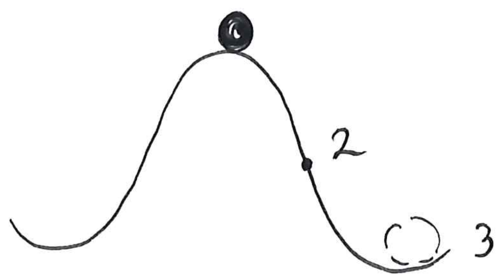
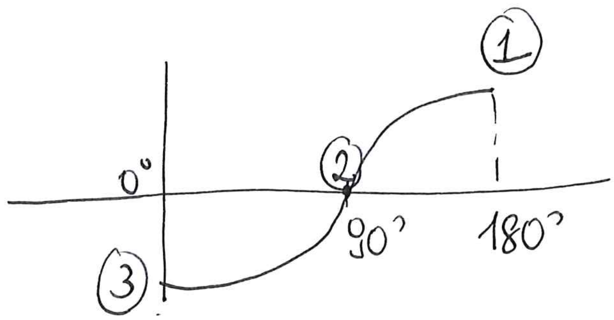
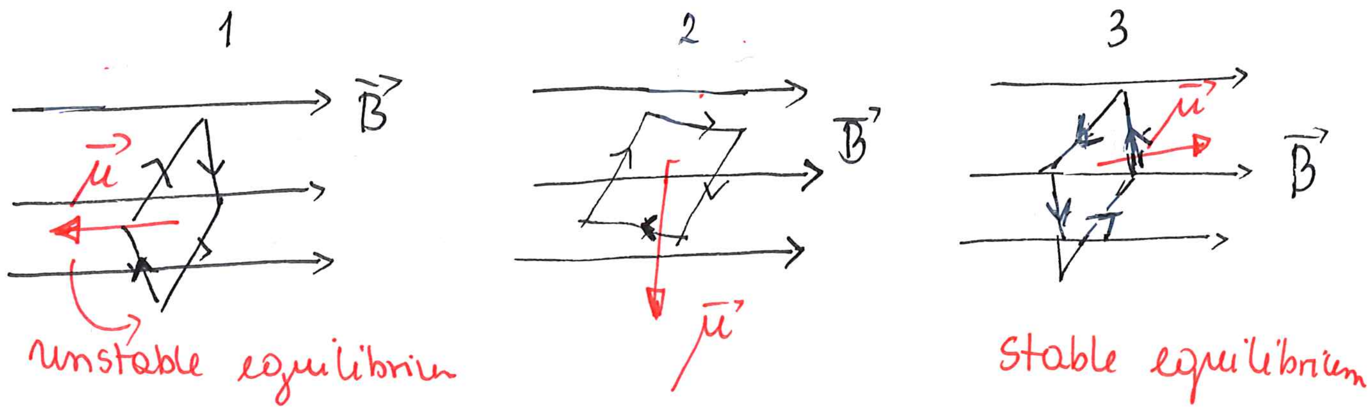
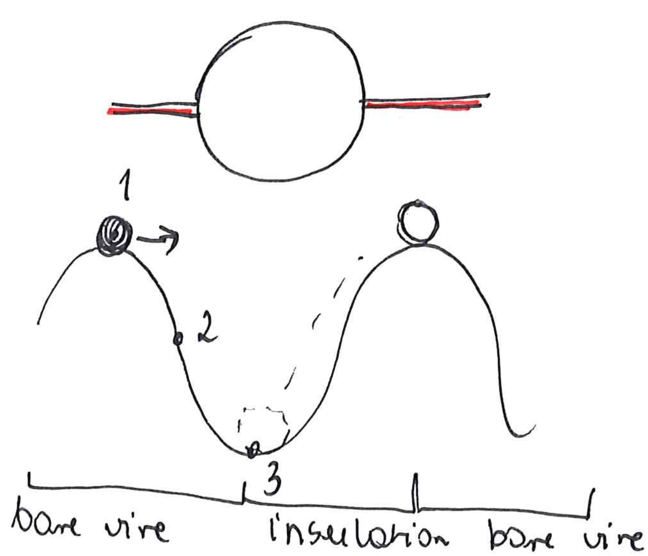




$$U_E = -\vec{p} \cdot \vec{E}$$



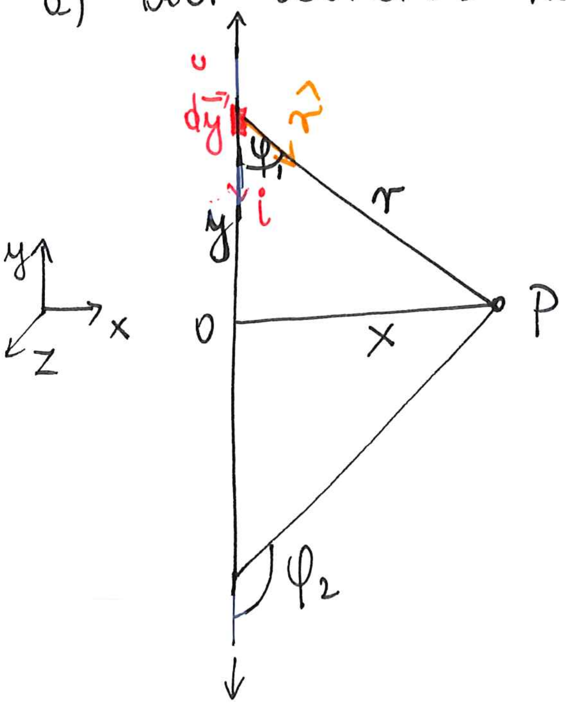




$$U = -\vec{\mu} \cdot \vec{B}$$

Infiniettly long current carrying wire

a) Biot-Savart's law



$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{l}\times\hat{r}}{r^2}$$

along y axis $d\vec{y}$

unit vector

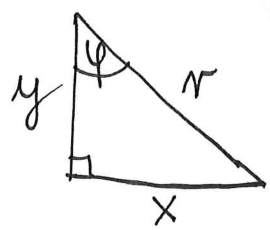
$\hat{r}$ points from the wire toward the point we would like to find magnetic field at.

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{y}\times\hat{r}}{r^2}$$

$$d\vec{y}\times\hat{r} = dy\cdot 1\cdot\sin\varphi\ \hat{k}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,dy\sin\varphi}{r^2}\hat{k}$$

All contributions are in the same direction



$$\frac{X}{r} = \sin\varphi$$

$$X = r\sin\varphi$$

$$r = \frac{X}{\sin\varphi} \qquad r^2 = \frac{X^2}{\sin\varphi}$$

Can just worry about the magnitude $dB = \frac{\mu_0}{4\pi}\frac{i\,dy\sin\varphi}{\frac{X^2}{\sin^2\varphi}} = \frac{\mu_0}{4\pi}\frac{i\,dy\sin^3\varphi}{X^2}$

Substitute

$$\frac{y}{X} = \cot\varphi \qquad y = X\cdot\cot\varphi$$

$$dy = -X\frac{d\varphi}{\sin^2\varphi}$$

$$dB = -\frac{\mu_0}{4\pi}\frac{i\cancel{X}\,d\varphi\,\sin^{\cancel{3}}\varphi}{X^{\cancel{2}}\cancel{\sin^2\varphi}} \qquad dB = -\frac{\mu_0 i}{4\pi X}\sin\varphi\,d\varphi$$

$$B = \int_{\varphi_1}^{\varphi_2} -\frac{\mu_0 i}{4\pi X}\sin\varphi\,d\varphi \qquad B = -\frac{\mu_0 i}{4\pi X}\int_{\varphi_1}^{\varphi_2}\sin\varphi\,d\varphi$$

$$B = -\frac{\mu_0 i}{4\pi X}\left[-\cos\varphi_2 + \cos\varphi_1\right] \qquad B = \frac{\mu_0 i}{4\pi X}\left[\cos\varphi_1 - \cos\varphi_2\right]$$