12. When an atom is placed in an external magnetic field, it experiences a perturbation given by $\hat{\mathcal{H}}' = -i\beta H \frac{d}{d\phi}$ where $\beta = \frac{e\hbar}{2mc}$ and H is the strength of the field which is assumed to be along the z-axis. Calculate the splitting of the d state of the hydrogen atom (neglect spin degeneracy)

The matrix of the perturbation is

Show how!

$\hat{\mathcal{H}}'$	$\|2\,-2\rangle$	$\|2\,-1\rangle$	$\|2\,0\rangle$	$\|2\,1\rangle$	$\|2\,2\rangle$
$\langle 2,-2\|$	$-2\beta H$	0	0	0	0
$\langle 2\,-1\|$	0	$-\beta H$	0	0	0
$\langle 2\,0\|$	0	0	~~βH~~ 0	0	0
$\langle 2\,1\|$	0	0	0	βH	0
$\langle 2\,2\|$	0	0	0	0	$2\beta H$

This is already diagonal. Therefore, the splitting is

$|2\,2\rangle$ — $2\beta H$
$|2\,1\rangle$ — βH
$|2\,0\rangle$ — 0
$|2\,-1\rangle$ — $-\beta H$
$|\,\,\,\rangle$ — $-2\beta H$

Why is m_ℓ called the magnetic quantum number?