A rigid, uniform disc of mass $m$, radius $a$, magnetic moment $\mathbf{M}$, is about to roll under gravity from a stationary position on a step, as shown, when it is brought to equilibrium by a vertical magnetic field $B$. $\mathbf{M}$ makes an angle $\theta$ with the vertical, and is oriented perpendicular to the radius vector from the disc center to $S$ at the step corner, which exerts a net force $\mathbf{F}$ on the disc at $S$.

(a). For the particular case when $MB = mga$, draw a sketch showing the gravitational potential energy $U_g$ and magnetic potential energy $U_m$ as functions of $\theta$ for $0 \leq \theta \leq \pi/2$.

(b). Explain why the equilibrium is stable, neutral or unstable, as the case may be.

(c). For the general case find how the equilibrium value of $\theta$ depends on $m$, $M$, $g$, $B$ and $a$.

(d). Calculate the smallest coefficient of friction $\mu$ at the step required for stability.