(a) We use a mutual inductance argument.

Approximate the particle as a small circular loop with radius \( r \) and current \( I = m/(\pi r^2) \). We will take \( r \to 0^+ \) at the end.

Suppose there is a current \( I' \) flowing through the large loop. The \( B \)-field at the particle’s location is

\[
B = \frac{\mu_0 I'}{2R},
\]

so the flux through the small loop is

\[
\Phi_B = \pi r^2 B = \mu_0 \pi r^2 \frac{I'}{2R}.
\]

Hence the mutual inductance of the two loops is

\[
M = \frac{\Phi_B}{I'} = \frac{\mu_0 \pi r^2}{2R}.
\]

By symmetry of mutual inductance, the flux through the large loop due to the small loop is

\[
\Phi_B' = MI = \frac{\mu_0 m}{2R}
\]

as desired.

(b) The \( B \)-field at the center of the loop is \( B = \mu_0 I/2R \). Thus the energy required to flip the dipole is

\[
2mB = \frac{\mu_0 m I}{R}.
\]

(c) The EMF induced by the rotating dipole is equal to

\[
\mathcal{E} = -\frac{\partial \Phi_B}{\partial t},
\]

which consumes an electrical energy

\[
E = \int I \mathcal{E} \, dt = -I \left( \Phi_{B,f} - \Phi_{B,i} \right).
\]

From part (a), this expression simplifies to

\[
E = -\frac{\mu_0 m I}{R},
\]

which agrees with the energy from part (b).