The Radial Equation

$$\frac{1}{R}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) - \frac{2mr^2}{\hbar^2}[V(r) - E] = \ell(\ell+1);$$

The angular part of the wave function, $Y(\theta,\phi)$, is the same for *all* spherically symmetric potentials.

The actual *shape* of the potential, $V(r)$, affects only the *radial* part of the wave function, $R(r)$.

Variable change:

$$u(r) \equiv rR(r) \quad \Rightarrow \quad \begin{aligned} R &= u/r, \\ dR/dr &= \left[r(du/dr) - u\right]/r^2, \\ (d/dr)\left[r^2(dR/dr)\right] &= rd^2u/dr^2, \end{aligned}$$

We get the **radial equation:**

$$\boxed{-\frac{\hbar^2}{2m}\frac{d^2u}{dr^2} + \left[V + \frac{\hbar^2}{2m}\frac{\ell(\ell+1)}{r^2}\right]u = Eu.}$$

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It is *identical in form* to the one-dimensional Schrödinger, where:

$$V_{\text{eff}}=V+\frac{\hbar^2}{2m}\frac{\ell(\ell+1)}{r^2},$$

is the **effective potential,** which contains a **centrifugal term**: $\left(\hbar^2/2m\right)\left[\ell(\ell+1)/r^2\right]$

It tends to throw the particle outward (away from the origin), just like the centrifugal (pseudo-)force in classical mechanics.

The normalisation conditions is: $\int_0^\infty |u|^2\,dr=1.$

which is potential *V(r)* specific.