4) $\frac{\beta}{r^2}$ of the same form as the centrifugal potential

$$\Rightarrow V_{eff}(r) = -\frac{\alpha}{r} + \frac{L_z^2/2m + \beta}{r^2}$$

From Kepler orbits we learned that

$$\phi(r) = \frac{L_z}{m}\int \frac{dr}{r^2\sqrt{\frac{2}{m}(E - V_{eff}(r))}}$$

$$\Rightarrow r = \frac{L_{eff}^2/m\alpha}{1 + e\cos\frac{L_{eff}}{L_z}\phi} \qquad e = \sqrt{1 + \frac{2EL_{eff}^2}{m\alpha^2}}$$

if $\frac{L_{eff}}{L_z}$ not equal to an integer than

the orbit is not closed, otherwise the same as for Kepler orbits.