The integral can be rewritten in the spherical coordinate system as

$$\iiint_D r^{-p} r^2 dr \sin\theta \, d\theta d\phi$$

In the special case of (a, b, c) where we have spherical symmetry, the integral will become

$$4\pi \int_0^1 r^{2-p} dr$$

$$4\pi \int_1^\infty r^{2-p} dr$$

$$4\pi \int_0^\infty r^{2-p} dr$$

respectively.

Thus, for (a), we need $2 - p > -1$, which gives $p < 3$.

For (b), we need $2 - p < 0$, which gives $p > 2$.

For (c), it will be the intersection of what we have above, thus $2 < p < 3$.