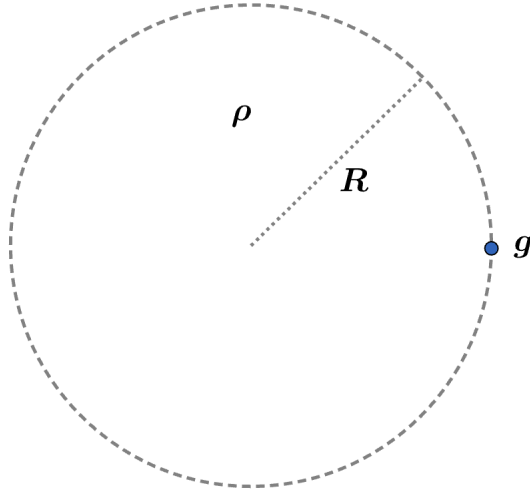# 2014 F=ma Exam: Problem 17

Kevin S. Huang

By the shell theorem, the gravitational field outside a uniform sphere is the same as that of a point at the center of the sphere with the same mass. Thus,

$$g = \frac{GM_{\text{enclosed}}}{R^2} \propto \frac{G(\rho R^3)}{R^2} \propto \rho R$$

Since the radius is fixed, we have $g \propto \rho$ so it remains to find how the density changes. When the cloud expands to radius $2R_0$, the same mass is spread over a larger volume. We have

$$M = \rho_0 \left(\frac{4}{3} \pi R_0^3 \right) = \rho' \left[\frac{4}{3} \pi (2R_0)^3 \right]$$

$$\rho_0 = 8\rho'$$

Since the new density $\rho' = \rho_0/8$,

$$g' = g_0/8$$

so the answer is $\boxed{C}$.