Mobility of a hard sphere in a dilute gas

The mobility constant $\mu$ in the equation $u = \mu F_{app}$ relates the steady state velocity $u$ of an object moving through a fluid to the external force applied to the object. In steady-state motion, the external force is balanced by the average force $F$ exerted by the fluid particles on the object: $F_{app} = -F$.

Show that the average force exerted by a dilute gas (density $n$, particle mass $m$, temperature $T$) on a slowly moving heavy hard sphere (radius $R$, velocity $u$ with $u \ll \langle v \rangle$) is

$$F = -\frac{8}{3} \sqrt{2\pi m k_B T R^2 n u}.$$

Solution: