Given: Standard British golf ball:
   \( m = 45.9 \pm 0.3 \text{g} \) (20 to 1)
   \( D = 44.1 \pm 0.3 \text{mm} \) (20 to 1)

Find:
(a) Density and specific gravity
(b) Estimate of uncertainties in calculated values

Solution:

Density is mass per unit volume, so

\[
\rho = \frac{m}{V} = \frac{\frac{4}{3} \pi R^3}{\frac{4}{3} \pi r^3} = \frac{m}{n^3} = \frac{\rho}{\rho_{20}}
\]

\[
\rho = \frac{m}{V} = \frac{1}{(0.0459 \text{g})} \frac{1}{\text{cm}^3} = 1260 \text{ kg/m}^3
\]

and

\[
SG = \frac{\rho}{\rho_{20}} = \frac{1260 \text{ kg/m}^3}{1000 \text{ kg/m}^3} = 1.26
\]

The uncertainty in density is given by

\[
\Delta \rho = \pm \left[ \left( \frac{\partial \rho}{\partial m} \right)^2 + \left( \frac{\partial \rho}{\partial V} \right)^2 \right]^{1/2}
\]

\[
\frac{\partial \rho}{\partial m} = \frac{\partial}{\partial m} \left( \frac{m}{V} \right) = \frac{1}{V}
\]

\[
\frac{\partial \rho}{\partial V} = \frac{\partial}{\partial V} \left( \frac{m}{V} \right) = -\frac{m}{V^2}
\]

\[
u_n = \pm \frac{0.3}{45.9} = \pm 0.654 \%
\]

\[
u_r = \pm 3 \%
\]

Thus

\[
\Delta \rho = \pm \left[ (0.654)^2 + (-3)^2 \right]^{1/2} = \pm \left[ (0.654)^2 + (-3(0.130)^2) \right]^{1/2}
\]

\[
\Delta \rho = \pm 2.29 \%
\]

\[
u_m = \pm 2.29 \%
\]

\[
u_m = \pm 0.0289
\]

Summarizing

\[
\rho = 1260 \pm 28.9 \text{ kg/m}^3 \quad (20 \text{ to } 1)
\]

\[
SG = 1.26 \pm 0.0289 \quad (20 \text{ to } 1)
\]