Solution to Problem 205F:

The definitions of the head coefficient, ψ, and the flow coefficient, ϕ, are

$$\psi = gH/R^2\Omega^2 \quad \text{and} \quad \phi = Q/(A\Omega R) \tag{1}$$

where H is the head rise in meters, Q is the volume flow rate, A is the cross-sectional area ($A = \pi R^2$) and ΩR is the velocity of the tips of the blades where Ω is the rotational speed (in radians/second) and R is the impeller radius.

Therefore with the values given

$$0.2 = \frac{9.8 \times 10}{R^2\Omega^2} \quad \text{and} \quad 0.08 = \frac{0.1}{\pi\Omega R^3} \tag{2}$$

or

$$\Omega^2 R^2 = 490 \quad \text{and} \quad \Omega R^3 = 0.398 \tag{3}$$

Solving for R:

$$R \quad = \quad (0.398^2/490)^{1/4} \quad = \quad 0.134m \quad = \quad 13.4cm \tag{4}$$

and for Ω:

$$\Omega \quad = \quad 165.2 radians/sec \quad = \quad 1578 rpm \tag{5}$$