1. Work the following problems from the text:

   (a) Section 11.4: 19, 28, 30, 31, 34
   (b) Section 11.5: 20, 32, 34, 47, 48
   (c) Section 11.6: 22, 23, 26, 40, 42, 44

2. Two surfaces are called orthogonal at a point of intersection \( P \) if their normals are perpendicular at that point.

   (a) Show that surfaces with equations \( F(x, y, z) = 0 \) and \( G(x, y, z) = 0 \) are orthogonal at a point \( P \) where \( \nabla F \neq 0 \) and \( \nabla G \neq 0 \) if and only if

\[
F_x G_x + F_y G_y + F_z G_z = 0 \text{ at } P
\]

   (b) Use part (a) to show that the \( z^2 = x^2 + y^2 \) and \( x^2 + y^2 + z^2 = r^2 \) are orthogonal at every point of intersection.

   (c) Can you see why this is true without using calculus? If so, how?

3. Suppose that at a given point \( P \), the directional derivatives of \( f(x, y) \) are known in two nonparallel directions described by unit vectors \( \hat{u} \) and \( \hat{v} \). In particular, suppose that \( df/ds = A \) in the \( \hat{u} \) direction and \( df/ds = B \) in the \( \hat{v} \) direction. Is it possible to find \( \nabla f \) at the point \( P \)? If so, how do you do it?