Difficulty guide for worksheet:	
C-level or B-level exam problem:	1, 2, 3, 5a
A-level exam problem or challenge for extra study:	4, 5b
beyond the scope and/or removed from syllabus:	none

1. Find the rate of change of f at the point P in the direction $\boldsymbol{u}$.

(a) $f(x, y) = \sin(xy + y^2)$, $P = (0, \sqrt{\pi})$, $\boldsymbol{u} = \langle 2, -3\rangle$

(b) $f(x, y) = \sqrt{1 + x^2y + xy^2}$, $P = (3, 4)$, $\boldsymbol{u}$ is in direction toward origin

(c) $f(x, y) = \dfrac{xy}{1 + xy^3}$, $P = (-1, 2)$, $\boldsymbol{u}$ is in direction 30 degrees south of west

(d) $f(x, y, z) = xyz^2 + x^3z$, $P = (1, -1, 1)$, $\boldsymbol{u} = \langle 0, 1, 1\rangle$

2. The temperature at the point (x, y, z) is given by $T(x, y, z) = xyz^{-1}$. A particle travels on the path given by $\boldsymbol{r}(t) = \langle e^t, t, t^2\rangle$. Find the rate of change of the temperature along the particle's path at $t = 1$.

3. Suppose that $\boldsymbol{\nabla} f_P = \langle 2, -4, 4\rangle$. Is f increasing or decreasing at P in the direction $\boldsymbol{v} = \langle 2, 1, 3\rangle$?

4. The height of some terrain is modeled by the equation $h = xe^{x^2-y}$. You are currently standing on the terrain above the point $P = (1, 1)$. Assume the positive y-axis points in the north direction.

(a) If you travel from P in the northerly direction, what angle of inclination do you measure?

(b) Suppose you decide to travel from P in the direction of steepest descent. Find the compass angle along which you should initially travel. (Assume the angle is measured anticlockwise from the positive x-axis.)

(c) What is the steepest possible angle of inclination at P?

(d) Your friend, who also starts at P, does not want to exert himself, and so he decides to walk along the terrain, keeping a constant height. Find the compass angle along which your friend should initially travel from P. (Assume the angle is measured anticlockwise from the positive x-axis.)

5. Find a function f with the given gradient.

(a) $\boldsymbol{\nabla} f = \left\langle y^2 \sin(xy^2) + 6x,\ 2xy \sin(xy^2)\right\rangle$

(b) $\boldsymbol{\nabla} f = \left\langle 2xyz^2,\ x^2z^2 + 8yz^3,\ 2x^2yz + 12y^2z^2\right\rangle$