EP375 Computational Physics

Topic 9

OPTIMIZATION

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Feb 2014
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1. **Introduction**

- Optimization is the term used for minimizing or maximizing a function.

- In general, it is sufficient to consider the problem of minimization only; maximization of \( f(x) \) is achieved by simply minimizing \( -f(x) \).

- The function \( f(x) \) that we want to optimize is called the **merit function** or **objective function**.
MATLAB fminsearch() Function

\[ x = \text{fminsearch}(\text{@func}, \ x_0) \]
returns the vector of independent variables that minimizes
the multivariate function \text{func}.
The vector \( x_0 \) contains the starting values of \( x \).

\[
>> \ x_{\text{opt}} = \text{fminsearch}(\text{@sin}, 1)
\]

\[
x_{\text{opt}} =
\]

\[
-1.5708
\]
Example:
Locate the minimum of the function \( f(x) = \exp(x)/x \)

**optfun.m**

```matlab
function y = optfun(x)
    y = exp(x)/x;
end
```

```
>> xmin = fminsearch(@optfun, 0.4);
xmin = 1.0000
```

```
>> [xmin, fmin] = fminsearch(@optfun, 0.4);
xmin = 1.0000
fmin = 2.7183
```
Example:
Locate the minimum of the function
\[ f(x, y) = 10x^2 + 3y^2 - 10xy + 2x. \]
Start with: \((x_0, y_0) = (0, 0)\).

```matlab
function y = optfun(x)
    y = 10*x(1)^2 + 3*x(2)^2 - 10*x(1)*x(2) + 2*x(1);
end
```

```matlab
>> x = fminsearch(@optfun, [0 0]);
x =
   -0.6000   -1.0000
```
**HW 1**

Locate the minimum of

\[
f(x, y) = (x-10)^2 + (y - 4)^2 + (z - 0.9)^2 + 3(1 - x*y*z)
\]

Start with: \((x_0, y_0, z_0) = (5, 5, 5)\).

**HW 2**

Find the maximum of the function

\[
f(x, y, z) = -2x^2 - 3y^2 - z^2 + xy + xz - 2y
\]

and confirm the result analytically.
HW 3

Using Plank’s formula for a black-body radiator, derive Wein law:

\[ k_B T \lambda_{\text{max}} = 0.2014 \]

or

\[ \lambda_{\text{max}} T = 0.0029 \text{ m} \cdot \text{K} \]

Hint: Plank formula is given by:

\[ u(\lambda) = \frac{8\pi hc}{\lambda^5} \frac{1}{\exp(hc / k_B T \lambda) - 1} \]

use dimensionless variable: \( x = \frac{hc}{k_B T \lambda} \)

and solve \( \frac{du}{dx} = 0 \)

The figure shows the cross section of a channel carrying water. Determine $h$, $b$ and $\theta$ that minimize the length of the wetted perimeter while maintaining a cross-sectional area of 6 m$^2$. (Minimizing the wetted perimeter results in least resistance to the flow.)
HW 5
Consider a box with open top to carry $V = 0.2 \, m^3$ waste water. The cost of material used to form the box is $C_m = 10 \, TL/m^2$ and welding cost is $C_w = 5 \, TL/m$. Design the box so that its total cost is minimum. Verify the result analytically.
HW 6

A child starts to swing at an initial angle $\theta_0 = 60^\circ$ from point A. Then, he passes though the minimum point B as shown in figure. At point C where the angular position is $\theta < \theta_0$ he jumps from swing and falls down at a distance $x$ from point B. Write a program to find the optimal value of $\theta$ such that the he can reach the maximum distance from the minimum point of the swing. Assume that the height of the swing is $h = 0.5$ m.
References

