P342/P745 Computer Lab

End-Semester examination (special), 2021

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Full marks: 25 Time: 3 hours

Marks are given in bold along with the questions. Attempt all.

1. A spring is attached to a rigid wall at one end and a force of $F = 2.5$ Newton is applied at the other. The spring constant increases with distance as $k(x) = \exp(x)$. For an arbitrary displacement x, the force acting on the system is $F(x) = F - x\exp(x)$. Find, using Newton-Raphson method, how far the spring can be stretched. **[5]**

2. Planck's spectral distribution of emissive power is given by

$$\epsilon_\lambda \, d\lambda = \frac{C_1}{\lambda^5} \frac{1}{e^{C_2/\lambda T} - 1} \, d\lambda$$

where $C_1 = 1.2 \times 10^{-16}$ and $C_2 = 1.4 \times 10^{-2}$ in S.I. unit. Use Simpson integration technique for $N = 10$ to determine total power emitted by sun at 6000 K within the visual range 400 – 700 nm. **[6]**

3. A certain 0.5 kg object is falling vertically freely through a given fluid. The table below is the data generated from this fall

velocity v (m/s)	net force f (N)
2.51	4.5
3.06	4.4
3.77	4.2
4.09	4.1
4.65	3.8
5.51	3.6
6.21	3.0
7.22	2.6
7.88	2.3
8.53	2.0
9.79	1.1
10.31	0.8
10.93	0.5
11.21	0.2

Use least-square method to fit the above data with the functions (i) $f = av + b$ and (ii) $f = av^b$. Determine a, b and the quality of fit for both the functions by calculating the *Pearson's* r,

$$r^2 = \frac{S_{xy}^2}{S_{xx}\, S_{yy}}$$

where the symbols have their usual meaning. **[8]**

4. Equation for heat conduction in a thin, un-insulated rod of length $L = 10$ m is

$$\frac{d^2T}{dx^2} + \alpha(T_a - T) = 0$$

where the heat transfer coefficient $\alpha = 0.01\,\mathrm{m}^{-2}$ parametrizes heat dissipated to the surrounding air and $T_a = 20^o$C is the ambient temperature. If $T(x = 0) = 40^o$C and $T(x = L) = 200^o$C, solve the boundary value problem using *Shooting Method* with *RK4* integrator and determine at what x the temperature $T = 100^o$C. **[6]**