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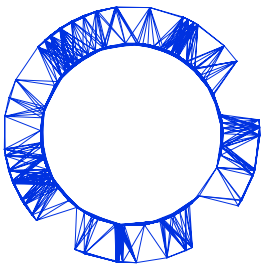

Confidential

Detailed Marking Scheme Experimental Problem 2

Viscoelasticity of a polymer thread

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v1.1

Viscoelasticity of a polymer thread (10 points)

Part A: Stress-relaxation measurements (1.9 points)

A.1

$\ell_0 \in [40, 50]$ cm	0.1
$\sigma_{\ell_0} \in [0.1, 0.5]$ cm	0.2
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

A.2

$P_0 \in [75, 85]$ gf	0.1
$\sigma_{P_0} \in [0.01, 0.1]$ gf	0.2
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

A.3

Table with times and weight	1.0
Total	1.0

[Wrong or missing units in the first two columns of the table, -0.2pt]

[Non-decimal time scale in column t (e.g. min:sec), necessary for the graphic in question D.2, -0.2pt]

[less than 20 points, -0.3pt]

[number of points $\in [20, 30]$, -0.2pt]

A.4

$\ell \in [45, 55]$ cm	0.1
$\sigma_\ell \in [0.1, 0.5]$ cm	0.2
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

Part B: Measurement of the streched thread diameter (1.5 points)

B.1

Reasonable sketch	0.6
Total	0.6

[no optimization of optical path (using mirrors), -0.6pt]

B.2

$D \in [1, 4]$ m	0.2
$\sigma_D \in [0.1, 3]$ cm	0.1
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

B.3

$\bar{x}$	0.1
$\sigma_{\bar{x}} \in [0.001\bar{x}, 0.1\bar{x}]$	0.2
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

B.4

$d \in [0.40, 0.55]$ mm, correctly calculated from B.3 and B.2	0.2
$\sigma_d \in [0.001, 0.05]$ mm, correctly calculated from B.3 and B.2	0.1
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

Part C: Changing to a new thread (0.3 points)

C.1

$\ell_0' \in [30, 35]$ cm	0.1
$\sigma_{\ell_0'} \in [0.1, 0.5]$ cm	0.2
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Wrong or missing units, -0.1pt]

Part D: Data analysis (5.7 points)

D.1

Fill F in Table 1, using of the correct algorithm $F = P_0 - P(t)$ for all the calculations	0.3
Total	0.3

[Errors in the calculation for some points (less than 50% of the points), -0.1pt]

[Errors in the calculation for some points (more than 50% of the points), -0.3pt]

D.2

Correct and complete representation of axis quantities, units and labels	0.1
Complete representation of all data points	0.2
Optimization of the axis span in order to maximize the use of the provided space (more than half of the area)	0.1
Total	0.4

Correct and complete representation of axis quantities, units and labels

[Missing labels in the axis, -0.1pt]

[Label values unequally spaced, -0.05 pt]

[Missing identification of the quantities in the axis, -0.05 pt]

[Missing or wrong units in the axis, -0.05 pt]

Complete representation of all data points

[Errors in the representation for some points (less than 50% of the points), -0.1 pt]

[Errors in the calculation for a significant number of points (more than 50% of the points), -0.2 pt]

D.3

ϵ, correctly calculated from A.1 and A.4	0.2
σ_ϵ, correctly calculated from A.1 and B.4	0.1
Total	0.3

[Incoherent use of significant digits, -0.1pt]

[Indication of units for ϵ, -0.1pt]

D.4

β, correctly calculated from D.3 and B.4	0.3
Total	0.3

[Wrong or missing units, -0.1pt]

D.5

Representation of a positive constant function $F(t)$	0.4
Total	0.4

D.6

Fill $\frac{\mathrm{d}F}{\mathrm{d}t}$ in Table 1	0.5
Total	0.5

[Wrong determination of $\mathrm{d}F/\mathrm{d}t$ values from either method, -0.5 pt]

[Use of points at t< 1000 s, -0.1 pt]

[Exclusively use of points at t< 1000 s, -0.5 pt]

D.7

Expression for expected dF(t)/dt	0.3
Total	0.3

D.8

Correct and complete graphical representation of axis quantities, units and labels	0.1
Complete representation of all data points and linear fit	0.2
Optimization of the axis span in order to maximize the use of the provided space (more than half of the area)	0.1
Reasonable value of τ_1	0.3
Reasonable value of E_1	0.3
Total	1.0

[No linearisation of $\mathrm{d}F/\mathrm{d}t$ function, -0.4 pt]

[Absence of a fitted straight line to extract the parameters, -0.8 pt]

[Bad fit of the straight line to the plotted points, -0.3 pt]

Correct and complete graphical representation of axis quantities, units and labels

[Missing labels in the axis, -0.1 pt]

[Label values unequally spaced, -0.05 pt]

[Missing identification of the quantities in the axis, -0.05 pt]

[Missing or wrong units in the axis, -0.05 pt]

Writing reasonable value of τ_1

[Unreasonable value of τ_1, expected to be in the order of 10^3 s, -0.2 pt]

[Wrong or missing units in τ_1, -0.1 pt]

Writing reasonable value of E_1

[Unreasonable value of E_1, expected to be in the order of 10^5 N m^{-2}, -0.2 pt]

[Wrong or missing units in E_1, -0.1 pt]

D.9

Reasonable value of E_0, expected to be in the order of 1.3×10^7 N m^{-2}	0.3
Total	0.3

[Wrong or missing units, -0.1 pt]

D.10

Fill $y(t)$ in Table 1 with correct values	0.3
Total	0.3

[Errors in the calculation for some points (less than 50% of the points), -0.2 pt]

[Errors in the calculation for a significant number of points (more than 50% of the points), -0.3 pt]

[Calculations for points at $t > 1000$ s, -0.1 pt]

D.11

Correct and complete graphical representation of axis quantities, units and labels	0.1
Complete representation of all data points and linear fit	0.2
Optimization of the axis span in order to maximize the use of the provided space (more than half of the area)	0.1
Reasonable value of τ_2	0.3
Reasonable value of E_2	0.3
Total	1.0

[No linearisation of dF/dt function, -0.4 pt; Absence of a fitted straight line to extract the parameters, -0.8 pt; Bad fit of the straight line to the plotted points, -0.3 pt]

Correct and complete graphical representation of axis quantities, units and labels

[Missing labels in the axis, -0.1 pt]

[Label values unequally spaced, -0.05 pt]

[Missing identification of the quantities in the axis, -0.05 pt]

[Missing or wrong units in the axis, -0.05 pt]

Writing reasonable value of τ_2

[Unreasonable value of τ_2, expected to be in the order of 10^2 s, -0.2 pt]

[Wrong or missing units in τ_2, -0.1 pt]

Writing reasonable value of E_2

[Unreasonable value of E_2, expected to be in the order of 10^5 N m-2, -0.2 pt]

[Wrong or missing units in E_2, -0.1 pt]

D.12

reasonable t_i	0.1
Reasonable t_f	0.2
Total	0.3

[t_f >initial time in the fit of the second component, -0.2 pt]

[Wrong or missing units, -0.1 pt]

D.13

Draw a line fit within $[t_\mathrm{i}, t_\mathrm{f}]$	0.2
τ_3 with an order of magnitude of $10^0 - 10^1$ s (< 100 s)	0.1
Total	0.3

[Wrong or missing units, -0.1 pt]

Part E: Measuring E in constant stress conditions (0.6 points)

E.1

E with the same order of magnitude of that in question D.9	0.4
Relative difference	0.2
Total	0.6

[Wrong or missing units, -0.2 pt]