RF Reflectometry of Single-Electron Circuits

Part A: Lumped element model of a co-axial transmission line (2.0 points)

A.1 (0.2 pt)
$v =$

A.2 (0.2 pt)
$E(r) =$

A.3 (0.3 pt)
$C_x =$

A.4 (0.3 pt)
$L_x =$

A.5 (1.0 pt)
i.

ii. $b/a =$

Part B: Hypothetical transmission line with return along a grounded plane (1.0 points)

B.1 (1.0 pt)
$Z_0 =$

Part C: Basics of RF reflectometry (1.2 points)

C.1 (1.0 pt)
$\Gamma =$

C.2 (0.2 pt)

Part D: The single electron transistor (points 3.3)

D.1 (1.5 pt)
i. $\varphi_n =$

ii. $\Delta E_n =$

D.2 (0.5 pt)
$E_c =$

D.3 (0.5 pt)

D.4 (0.8 pt)
i. $\tau =$
ii.

Part E: RF reflectometry to read out SET state (1.0 points)

E.1 (0.2 pt)
$\Delta\Gamma =$

E.2 (0.8 pt)
$L_0 =$
$\Delta\Gamma =$

Part F: Charge sensing with a single lead quantum dot (1.5 points)

F.1 (1.0 pt)
$\omega_{\mathrm{rf}} =$
$Z_C =$

F.2 (0.5 pt)

X-ray jets from active galactic nuclei

Part A: 1D fluid model of a jet (3.8 points)

A.1 (0.3 pt)

$n'(s) =$

A.2 (0.2 pt)

$F_{\rm p}(s) =$

A.3 (0.5 pt)

A.4 (0.6 pt)

A.5 (0.6 pt)

$\frac{dP_{\rm j}}{ds} =$

A.6 (0.4 pt)
Expression for calculating $\dot{M}$:

$\dot{M}_1 =$

$\dot{M}_2 =$

A.7 (0.5 pt)
Expression:
$\Pi =$

Numerical:
$\Pi =$

A.8 (0.5 pt)

$F_{\mathrm{Pr}} =$

A.9 (0.2 pt)
Relationship:

$\%$ deviation $=$

Part B: Gas of ultra relativistic electrons (2.2 points)

B.1 (0.2 pt)

B.2 (0.8 pt)

$\frac{\Delta p_z}{\Delta t} =$

B.3 (0.6 pt)

B.4 (0.6 pt)

Part C: Synchrotron emission (1.7 points)

C.1 (0.7 pt)

$\Omega =$

C.2 (0.5 pt)

$\Delta t =$

C.3 (0.3 pt)

$\nu_{\mathrm{chr}} =$

C.4 (0.2 pt)

$\tau =$

Part D: Synchrotron emission from an AGN jet (2.3 points)

D.1 (0.4 pt)

$B =$

D.2 (1.0 pt)

$f(\epsilon) =$

D.3 (0.3 pt)
Synchrotron cooling will make the distribution:
☐ shallower, ☐ steeper, ☐ other

D.4 (0.6 pt)

AGN	Knot	Likely cause of cooling	Question parts which support your conclusion
Cen A	AX1C	☐ synchrotron cooling ☐ adiabatic expansion ☐ neither	
Cen A	BX2	☐ synchrotron cooling ☐ adiabatic expansion ☐ neither	
M87	HST-1	☐ synchrotron cooling ☐ adiabatic expansion ☐ neither	
M87	Knot A	☐ synchrotron cooling ☐ adiabatic expansion ☐ neither	

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Part A (10.0 points)

A.1 (1.0 pt)

$\mathbf{F}_{\text{ext}} =$

A.2 (0.8 pt)

$\boldsymbol{\tau}_{\text{ext}} =$

A.3 (0.4 pt)

A.4 (0.8 pt)

$\omega =$

A.5 (1.0 pt)

$E_T =$

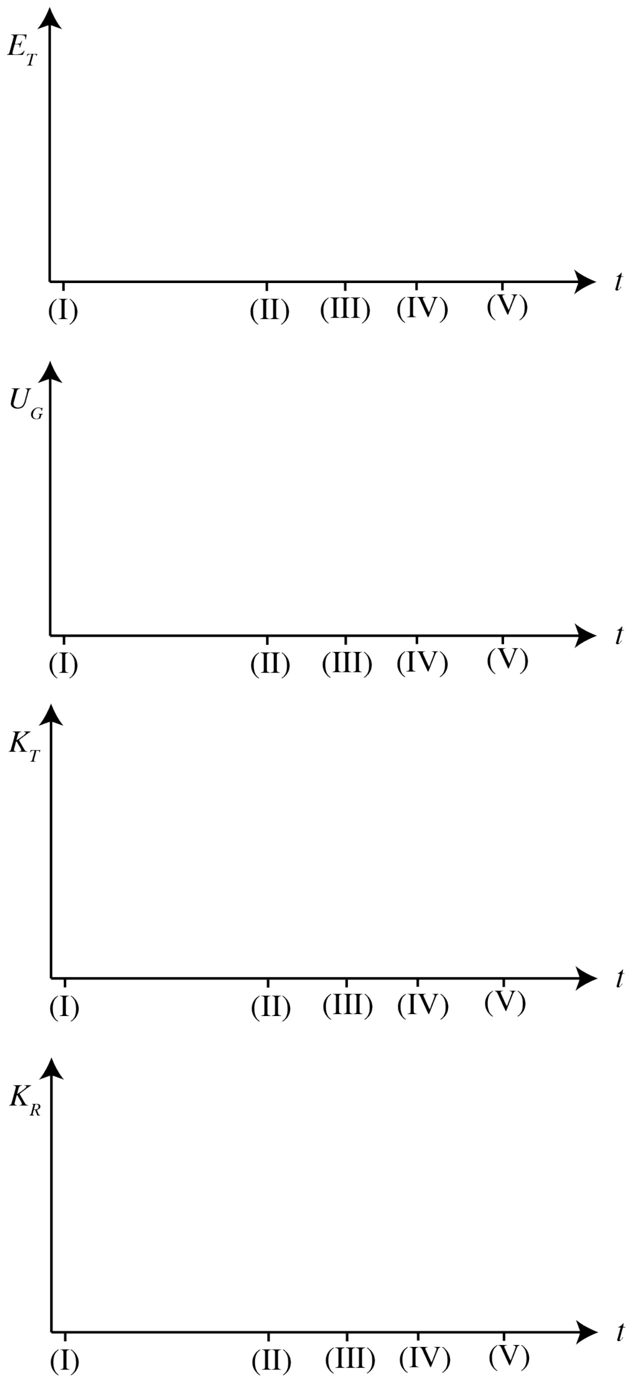
A.6 (0.4 pt)

$\frac{dL_z}{dt} =$

A.7 (1.4 pt)

$\frac{dE_T}{dt} =$

A.8 (2.0 pt)



A.9 (0.5 pt)

$k =$

A.10 (1.7 pt)

$\mathbf{v} =$