Theoretical Competition
25 April 2010

Student Code | | | | |

Question Number 2

Page No. | | Total No. | |

ANSWER SHEET

Theoretical Question 2
Strong Resistive Electromagnets

Do not write in any box marked with a solidus (oblique stroke, /).

Part A. Magnetic fields on the axis of the coil

(a) x-component $B(x)$ of the magnetic field on the axis (in terms of a, D, I, ℓ, μ_0).

Expression of $B(x) =$							
1.0 pt	/	/	/	/	/	/	/

(b) The current I_0 when $B(0) = 10.0\ \mathrm{T}$ (expressed in terms of a, D, $B(0)$, ℓ, μ_0).

Expression of $I_0 =$ Value of $I_0 =$							
0.4 pt	/	/	/	/	/	/	/

Part B. The upper limit of current

(c) The outward normal force per unit length $\Delta F_n / \Delta s$ (in terms of a, D', I, μ_0).

Expression of $\dfrac{\Delta F_n}{\Delta s} =$							
1.2 pt	/	/	/	/	/	/	/

The tension F_t along the wire (in terms of a, D', I, μ_0).

Expression of $F_t =$							
0.6 pt	/	/	/	/	/	/	/

ANSWER SHEET

(d) The current I_{b} at which the turn will break (expressed in terms of a, b, D, σ_{b} , μ_0).

Expression of I_{b} = Value of I_{b} =							
0.8 pt	/	/	/	/	/	/	/

The magnetic field B_{b} at O when the current is I_{b} (expressed in terms of a, I_{b} , μ_0).

Expression of B_{b} = Value of B_{b} =							
0.4 pt	/	/	/	/	/	/	/

Part C. Rate of temperature rise

(e) The power density of heat generation in the coil.

Expression: Value:							
0.5 pt	/	/	/	/	/	/	/

(f) The time rate of change $\dot{T}$ of temperature in the coil.

Expression of $\dot{T}$ = Value of $\dot{T}$ =							
0.5 pt	/	/	/	/	/	/	/

ANSWER SHEET

Part D. A pulsed-field magnet

(g) Expressions for the inductance L and resistance R.

Expression of $L =$ Expression of $R =$							
0.6 pt	/	/	/	/	/	/	/

Values of inductance L and resistance R.

Value of $L =$ Value of $R =$							
0.4 pt	/	/	/	/	/	/	/

(h) Expressions for α and ω (in terms of R, L, and C).

Expression of $\alpha =$ Expression of $\omega =$							
0.8 pt	/	/	/	/	/	/	/

Values of α and ω.

Value of $\alpha =$ Value of $\omega =$							
0.4 pt	/	/	/	/	/	/	/

ANSWER SHEET

(i) Expression of I_m (in terms of $\alpha, \omega, \theta_0, V_0$ and C).

Expression of I_m =							
0.6 pt	/	/	/	/	/	/	/

Maximum initial voltage V_0b for which I_m will not exceed I_b of Problem (d).

Value of V_0b =							
0.4 pt	/	/	/	/	/	/	/

(j) The total amount of heat ΔE dissipated in the coil (in terms of $\alpha, \omega, \theta_0, V_\mathrm{0b}$ and C).

Expression of ΔE = Value of ΔE =							
1.0 pt	/	/	/	/	/	/	/

The temperature increase ΔT of the coil.

Expression of ΔT = Value of ΔT =							
0.4 pt	/	/	/	/	/	/	/