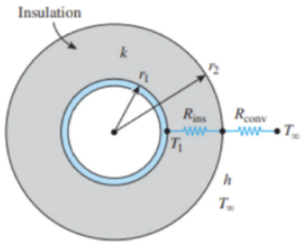
Assignment-02

Consider a cylindrical pipe of outer radius r1 whose outer surface temperature T1 is maintained constant. The pipe is now insulated with a material whose thermal conductivity is k and outer radius is r2. Heat is lost from the pipe to the surrounding medium at temperature T`, with a convection heat transfer coefficient h. Plot Q(heat transfer) vs r for the sphere.



In cylinder; $R_{cylinder} = R_{ins} = \frac{\ln[r_2/r_1]}{2\pi kL}$

$$R_{conv.} = \frac{1}{hA}$$

$$\therefore R_{total} = \frac{\ln[r_2/r_1]}{2\pi kL} + \frac{1}{h[2\pi r_2 L]}$$

$$\therefore \dot{Q} = \frac{\Delta T}{R_{total}}$$

$$\dot{Q} = \frac{\Delta T}{\frac{\ln(r_2/r_1)}{2\pi kL} + \frac{1}{h(2\pi r_2 L)}}$$

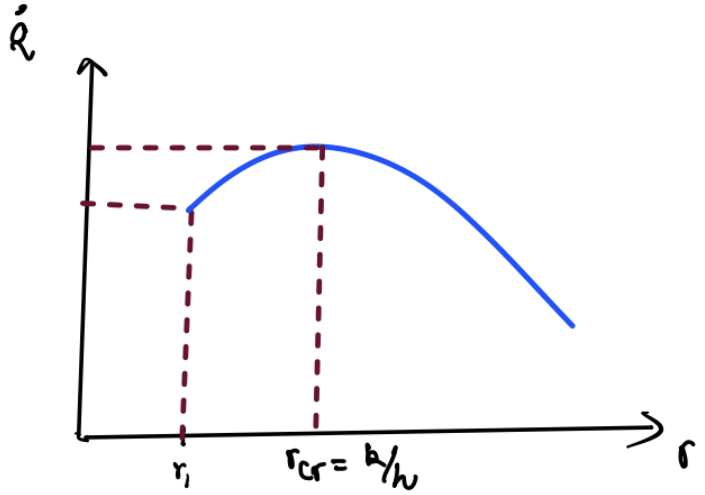
finding $r_{critical}$

$$\frac{dR_{total}}{dr_2} = 0.$$

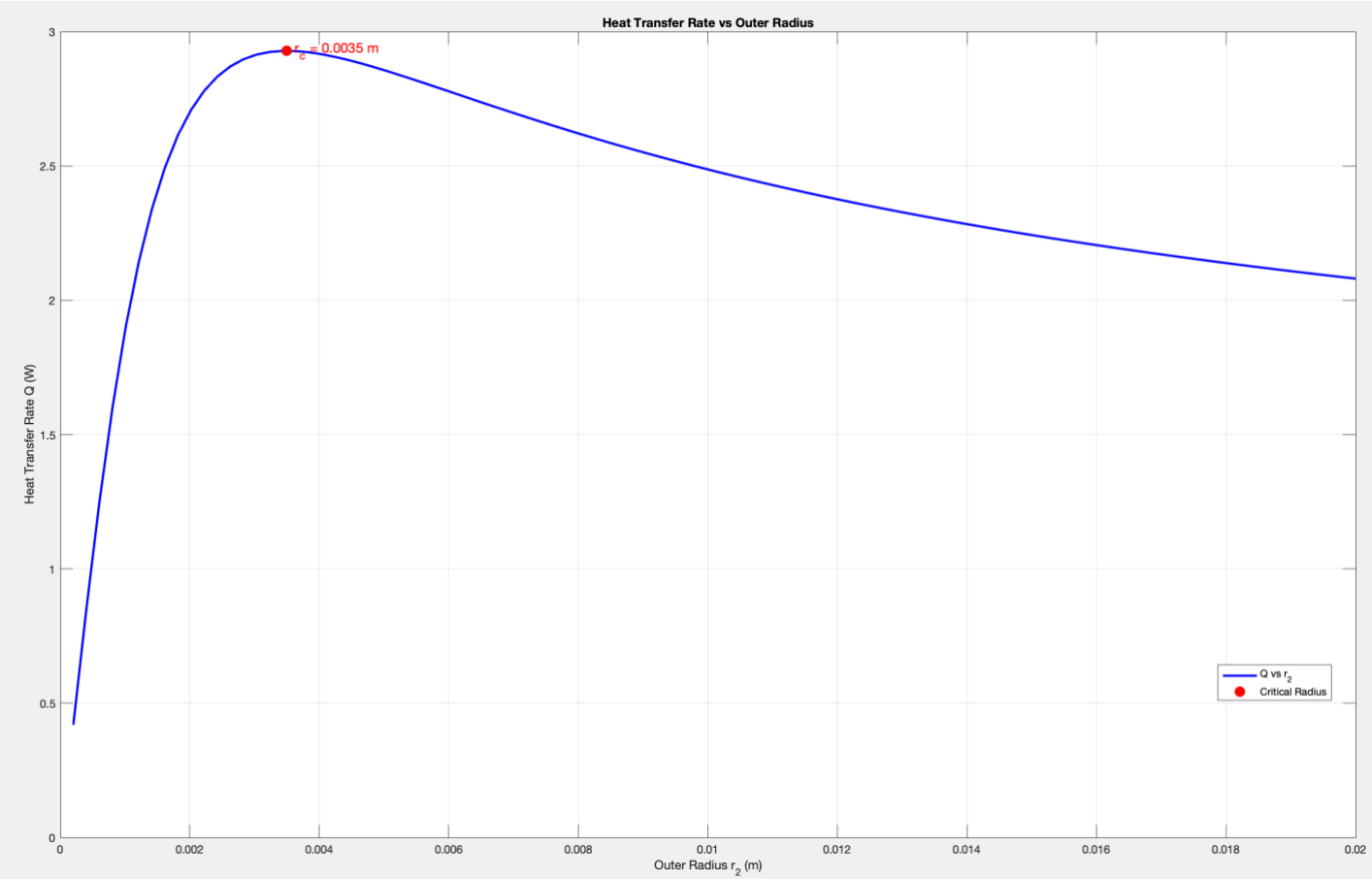
$$\Rightarrow \frac{1}{2\pi kL r_2} - \frac{1}{h 2\pi r_2^2 L} = 0$$

$$\Rightarrow h 2\pi r_2^2 L = 2\pi k L r_2$$

$$\rightarrow r_2 = \frac{k}{h} = r_{critical}$$



PLOT:



CODE:

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r1 = 0.001; % in m (inner radius of pipe)
k = 0.035; % Thermal conductivity of glass wool (W/mK)
L = 1; % Length of cylinder (m)
h = 10; % Convective heat transfer coefficient (W/m²K)

% outer radius values ranging from 0 to 0.02 m
r2 = linspace(0, 0.02, 100);

% total thermal resistance
R = @(r2) log(r2/r1)./(2*pi*k*L) + 1./(h*2*pi*r2*L);
T1 = 50; % °C (outer surface temperature of cylinder pipe)
T2 = 20; % °C (ambient Temperature)

% Heat transfer rate function
Q = @(r2) (T1-T2)./R(r2);
Q_values = Q(r2);

% finding the critical radius for cylinder
r_critical = k/h;
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```
% Ensure r_critical is within r2 range
if r_critical > min(r2) && r_critical < max(r2)
    Q_critical = Q(r_critical); % Get corresponding Q value
else
    Q_critical = NaN; % Avoid plotting if outside range
end

% Plotting Q vs r2
figure;
plot(r2, Q_values, 'b', 'LineWidth', 2);
hold on;
plot (r_critical, Q_critical,'ro','MarkerSize',9,'MarkerFaceColor', 'r');
text(r_critical, Q_critical, sprintf('  r_c = %.4f m', r_critical), 'FontSize', 12, 'Color', 'r');
xlabel('Outer Radius r_2 (m)');
ylabel('Heat Transfer Rate Q (W)');
title('Heat Transfer Rate vs Outer Radius');
legend('Q vs r_2', 'Critical Radius', 'Location', 'Best');
grid on;
hold off;
```