Q1. (20%) A worker pull a box of mass m across a level floor using a massless rope that makes angle $\theta$ with the horizontal. The coefficient of static and kinetic friction between box and floor is $\mu_s$ and $\mu_k$ separately. What rope tension is required to move the box at constant velocity along $x$-direction?

![Diagram of a box being pulled by a rope at an angle $\theta$.]

Q2. (20%) A Carnot engine extracts 240 J of the heat from a high temperature reservoir (with temperature $T_h$) during each cycle. It rejects 100 J of the heat to a reservoir at 15 °C. (a) What is Carnot cycle? (b) How much work does the engine do in one cycle? (c) What is its efficiency? (d) What is the value of $T_h$ (°K)?

![Diagram of a Carnot engine circuit.]

Q3. (20%) In the circuit as shown in the figure, there are five resistor ($R_1$, $R_2$, $R_3$, $R_4$, $R_5$) and one voltage source ($V_0$) in the circuit. (a) Find the value of $I_3$. (b) In what condition does $I_3$ equal to zero. (i.e. There is no current flow through $R_3$ in this case.)

![Diagram of a circuit with multiple resistors and a voltage source.]

Q4. (20%) A coaxial cable consists of an inner conductor of radius $a$ and outer conductor of radius $b$. The permittivity constant is $\varepsilon_0$ and the permeability is $\mu_0$. (a) What is the capacitance per unit length of the cable? (b) If the current flows along inner conductor and back along the outer. What is the inductance per unit length of the cable?

![Diagram of a coaxial cable.]

Q5. (20%) Finish the table in terms of $m$, kg, sec. and Coul.

<table>
<thead>
<tr>
<th>Power (example)</th>
<th>Magnetic field</th>
<th>Inductance</th>
<th>Capacitance</th>
<th>Newton</th>
<th>Magnetic field</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Watt</td>
<td>1 Tesla</td>
<td>1 Henry</td>
<td>1 Farad</td>
<td>1 N</td>
<td>1 Gauss</td>
</tr>
<tr>
<td>$= \frac{m^2 \times kg}{sec^3}$</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>=</td>
</tr>
</tbody>
</table>
1. Find the limit of the following questions, and give your reason. (每題 8 分)

(a) \( \lim_{x \to 0} \frac{4x^2}{1+3x^2} \)
(b) \( \lim_{x \to 2} \frac{\sin(x-2)}{x-2} \)

(c) \( \lim_{x \to 0} \frac{1}{x^2(x+1)^2} \)
(d) \( \lim_{x \to 0} \left( \frac{4}{x^2} - \frac{2}{1-\cos(x)} \right)^{\frac{1}{3}} \)

(e) \( \lim_{x \to 0} \frac{2x^2 - 7x}{3x} \)

2. (a) Find the curve of \( r = 4 \cos \theta \) (8 分)
(b) Find the area bounded by the graphs of \( x^2 + y^2 = 4 \) and \( r = 4 \cos \theta \) (12 分)

3. Find the answer of following questions: (每題 10 分)

(a) \( \int \frac{1}{\sqrt{4 + e^x}} \, dx = ? \)
(b) \( \int e^{\frac{t^x}{\sqrt{t}}} \, dx = ? \)

(c) \( f(x) = \cos^4(x^3 + 3x) \), find \( f'(x) = ? \)

4. Determine series \( \sum_{n=1}^{\infty} \frac{1}{n(n+2)} \) is Convergence or Divergence? give your reason. (10 分)

And, if series is convergence, find the sum of this infinite series.