Instruction: Hand in your work with name and code directly to my hand by 10.30 am. of the due date. DO NOT copy homework from your classmates or lend it to others. Anyone who violates this regulation will be given -10 for the homework.

1. Find the differential equation relating a current source $i_s(t) = 5\cos(\omega t)$ with the current $i_L(t)$ in an inductor with inductance $L = 1$ H, connected in parallel with a resistor of $R = 1$ Ω. Assume a zero initial current in the inductor.
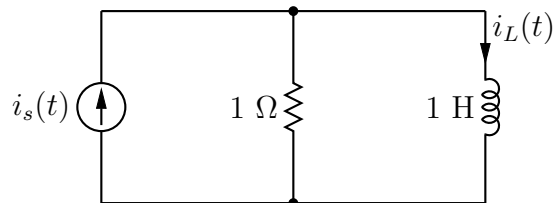

Figure 1: RL circuit: input $i_s(t)$ and output $i_L(t)$

   (a) Obtain a discrete equation from the differential equation using the trapezoidal approximation of an integral. (5 points)

   (b) Create a Python script or Matlab script to solve the difference equation for $T_s = 0.01$ sec and the frequency of $i_s(t)$ is $\omega = 0.5\pi$. Plot the input current source $i_s(t)$ and the approximate solution $i_L(nT_s)$ in the same figure. (5 points)

2. Define a function $z(t)$ as below,

$$z(t) = \begin{cases} 0, & t < 0 \\ 0.5t^2, & 0 \leq t < 0.5 \\ 0.5t - 0.125, & 0.5 \leq t < 2.5 \\ -0.5t^2 + 3t - 3.25, & 2.5 \leq t < 3.5 \\ -0.5t + 2.875, & 3.5 \leq t < 5.5 \\ 0.5t^2 - 6t + 18, & 5.5 \leq t < 6 \\ 0, & t > 6 \end{cases}$$

   Find $x(t)$ if

$$z(t) = \int_{-\infty}^{t} y(\tau)d\tau \quad \text{and} \quad y(t) = \int_{-\infty}^{t} x(\tau)d\tau$$

Test your result with either Matlab or Python. **Hint:** The below listing is an example of python code. If you use Jupyter Notebook, add a magic command `%matplotlib inline` at the beginning of your code to see the plot on the same windows. (10 points)

```python
import matplotlib
import matplotlib.pyplot as plt

import numpy as np
def zt(t):
    x = np.zeros(len(t))
    for k, tk in enumerate(t):
        if (tk < 0):
            x[k] = 0
        elif (tk >= 0) and (tk < 0.5):
            x[k] = 0.5*tk**2
        elif (tk >= 0.5) and (tk < 2.5):
            x[k] = 0.5*tk - 0.125
        elif (tk >= 2.5) and (tk < 3.5):
            x[k] = -0.5*tk**2 + 3*tk - 3.25
        elif (tk >= 3.5) and (tk < 5.5):
            x[k] = 2.875 - 0.5*tk
        elif (tk >= 5.5) and (tk < 6):
            x[k] = 18 + 0.5*tk**2 - 6*tk
        elif (tk >= 6):
            x[k] = 0
    return x

t = np.arange(-2,8,0.01)
z = zt(t)

ax = plt.subplot(3,1,3)
ax.set_yticks([-1.25, 0, 1.25])
ax.set_xticks([0, 0.5, 2.5, 3.5, 5.5, 6])
plt.plot(t,z)
plt.xlim(xmin=-2.0, xmax=8)
plt.ylim(ymin=-1.5, ymax=1.5)
plt.grid()
plt.xlabel("Time(s)")
plt.ylabel("$z(t)$")
```

3. Determine the power and the rms value for each of the following signals:

   (a) $10\cos\left(100t + \frac{\pi}{3}\right) + 16\sin\left(150t + \frac{\pi}{5}\right)$ (5 points)

(b) $(10 + 2\sin 3t)\cos 10t$ (5 points)

4. An amplifier with a 1Ω output resistance feeds an 8Ω loudspeaker. See Fig. 2a. The voltage source is

$$v_i(t) = 9\left[\sin(100t + 45°) + \cos(10,000t)\right]$$

(a) Find the average power in the loudspeaker. (5 points)

(b) Place a $100\ \mu F$ capacitor in parallel with the loudspeaker as shown in Fig. 2b. Find the average power in the loudspeaker. (5 points)
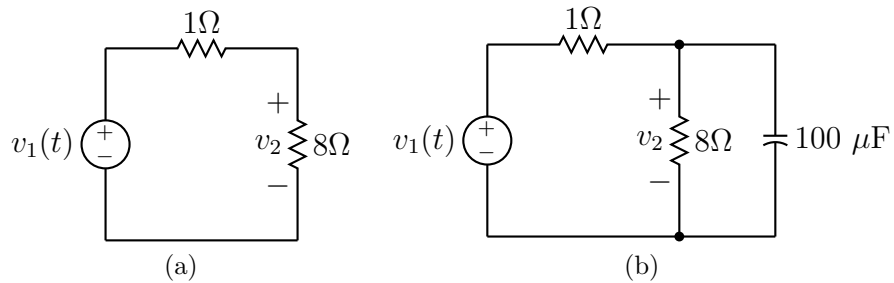
Figure 2: Loud speaker