1. (2D kinematics; 30%) As shown below, an object is launched from a 100-m building-top with a speed of 25 m/s in an angle of 60 degree from horizontal and lands on the ground. Use g = 10 m/s² for this problem.

- a. What is the vertical initial-launching speed? \( v_{0y} \approx 20.9 m/s \)
- b. How long does it take for the object to reach to the maximum height? \( t \approx 2.1 s \)
- c. What is the maximum height the object can reach above the ground? \( h \approx 12.3 m \)
- d. How long does it take for the object to reach the ground after reaching the maximum height? \( t \approx 5 s \)
- e. How far horizontally the object can reach away from the building when it lands? \( d \approx 80 m \) \( 90 m \)
- f. What is the vertical speed just before it hits the ground? \( v_{y} \approx 50 m/s \)

2. (Dynamics/energetics, system/sub-system, action/reaction forces; 40%) Two mass-blocks initially \( t = 0 \) at rest in the position A as shown below are being pushed by a force \( F \) on a frictionless table top to the position B.

- Given: \( F = 100 N \), \( m_1 = 16 kg \), \( m_2 = 4 kg \), and \( \Delta x = 20 m \).
- Find:
  - a. Net force on the two-block system, \( \sum F = 100 N \)
  - b. The value acceleration of two-block system, \( \frac{\Delta v}{\Delta t} = 5 m/s^2 \)
  - c. The value of action force on block-\( m_2 \), \( F_{action} = 20 N \)
  - d. The value of reaction force on block-\( m_1 \), \( F_{reaction} = 20 N \)
  - e. Net force on block-\( m_1 \), \( F_{net} = 80 N \)
  - f. Net force on the block-\( m_2 \), \( F_{net} = 70 N \)
  - g. Work done by the force \( F \) when the mass-blocks is being pushed from the position A to B, \( W = 2000 J \)
  - h. Kinetic energy of the mass-blocks at the position B, \( K = 12 J \)

3. (Heat capacity, latent heat of evaporation; 10%) In our lab experiment, 0.50 kg water at room temperature, 25 °C, was being heated by a heater. The temperature vs. time was measured as shown below (ideal case).

- Given the specific heat for water, \( C_w = 4186 J/(kg \cdot °C) \),
- Find:
  - a. the value of temperature increase at \( t = 180 s \), \( \Delta T = 75 °C \)
  - b. the value of energy transferred to water at \( t = 180 s \), \( Q = 150,915 J \)
  - c. energy transfer rate during the heating process from 0 to 180 s, \( P_{rate} = 812 W \)
  - d. At \( t = 300 s \), the heater was turned off and the amount of water was re-weighted to be 0.46 kg. What is the latent heat of water evaporation, \( L_h = 2.6 \times 10^6 J/kg \)
4. (Ohm’s law, and electric power, 10%) Two Incandescent light bulbs, specified as 60 W @ 120 V, are connected to the local power supply (V = 125 V) as shown below.

Find:

a. the value of resistance of the left light bulb, Ans. 240 Ω
b. the current passing the left light bulb, Ans. 0.52 A
c. the voltage on the right light bulb, Ans. 125 V
d. the actual electric power of right light bulb, Ans. 65 W

5. (Geometric optics; 10%)

Given: R = 20 mm, h₀ = 10 mm (height), and p = 40 mm.

Find:

a) Focal length, f. Ans. 10 cm
b) q, Ans. 13.3 cm
c) h, Ans. 3.3 cm
d) Ray-diagram confirmation [you must show 1-1’ and 2-2’rays] (6%)
e) Is the image real or virtual? Ans. Real

<table>
<thead>
<tr>
<th>Topics</th>
<th>Reference Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinematics (a ≠ 0)</td>
<td>v = v₀ + at</td>
</tr>
<tr>
<td></td>
<td>x = x₀ + v₀t + (1/2)at²</td>
</tr>
<tr>
<td></td>
<td>v² = v₀² + 2a(x - x₀)</td>
</tr>
<tr>
<td>Newton’s 2nd law</td>
<td>F_net = m a</td>
</tr>
<tr>
<td>Specific heat/latent heat</td>
<td>ΔQ = c m ΔT</td>
</tr>
<tr>
<td></td>
<td>L = ΔQ/Δm</td>
</tr>
<tr>
<td></td>
<td>ΔQ_eva = P_n Δt_eva</td>
</tr>
<tr>
<td>Ohm’s law</td>
<td>I = V/R</td>
</tr>
<tr>
<td></td>
<td>P = IV</td>
</tr>
<tr>
<td>Geometric optics</td>
<td>1/p + 1/q = 1/f; f = ± R/2</td>
</tr>
<tr>
<td></td>
<td>M = h₀h₁</td>
</tr>
<tr>
<td></td>
<td>M = - q/p</td>
</tr>
<tr>
<td>Math</td>
<td>sin(60°) = 3/2</td>
</tr>
<tr>
<td></td>
<td>cos(60°) = 1/2</td>
</tr>
</tbody>
</table>