1. \( R_{\text{net}} = H + LE + G + \Delta S \)

1a. Define the terms of the above equation.

- **\( R_{\text{net}} \)**: Net Radiation
- **\( H \)**: sensible heat flux (convective heating)
- **\( LE \)**: latent heat flux (evapotranspiration)
- **\( G \)**: ground heat storage
- **\( \Delta S \)**: change in storage

1b. The Bowen ration (\( H : LE \)) can be used to determine whether \( H \) or \( LE \) drive turbulent energy transfer from ecosystems to the atmosphere. Rank the following ecosystems in order of the average Bowen ratios they are likely to have (lowest =1, highest = 5).

   - Annual grassland (Southern California) 5
   - Palm forest (Central Amazon, Brazil) 2
   - Lake Merritt (Oakland, California) 1
   - Spruce forest (Alaska) 4
   - Corn field (lightly irrigated) (Northern California) 3 (flexible)

2a. A decomposition study was conducted in a warm temperate broadleaf forest with leaf litter and live roots in separate litterbags (15 cm x 15 cm). Approximate 8 g of tissues were placed in the bags at the start of the experiment. Ten bags of each tissue type were picked up at each of 5 sampling periods, dried at 65 °C and weighed to determine mass. Using an exponential decay model, calculate the decomposition rate constant (k in yr\(^{-1}\)) for the study (values are the means of the 10 bags per collection) using the percent mass remaining over time (in years):

<table>
<thead>
<tr>
<th></th>
<th>Leaves</th>
<th>Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial:</td>
<td>8.0 g</td>
<td>8.0 g</td>
</tr>
<tr>
<td>1 month:</td>
<td>5.7 g</td>
<td>7.2 g</td>
</tr>
<tr>
<td>3 months:</td>
<td>5.2 g</td>
<td>6.8 g</td>
</tr>
<tr>
<td>6 months:</td>
<td>4.0 g</td>
<td>6.2 g</td>
</tr>
<tr>
<td>12 months:</td>
<td>3.2 g</td>
<td>5.6 g</td>
</tr>
</tbody>
</table>

-0.92 for leaves using \( \ln(T_f/T_0) \); -0.81 using a full exponential model
-0.36 for roots using \( \ln(T_f/T_0) \); -0.33 using a full exponential mode

2b. Which tissue type has the fastest decay rate? **Leaves**

2c. What is the final percent mass remaining for each tissue type? **40% and 70%**
2d. The same forest has a litterfall productivity of 5 Mg/ha/yr, an average forest floor standing stock of 6 Mg/ha, and aboveground biomass of 120 Mg/ha. What is the mean residence time of the aboveground litter in years in this ecosystem? What is the decomposition rate constant? Why are the values different from the ones calculated above?

1.2
-0.83
all litter, not just leaves; effects of litter bags

2e. Graph the percent mass remaining by time (in years) for leaves and roots. Why might the patterns of the two curves be different? What are the likely relative controls on decomposition?

Could say quality of leaves is higher (less structural material) or could say microclimate is better aboveground (aeration, temperature); should address climate, litter quality, site conditions, and/or organisms in the answer.

3. \[ R_{growth} \] 0.8 g/m²/d
\[ R_{maintenance} \] 0.5 g/m²/d
\[ R_{ion\ uptake} \] 0.3 g/m²/d
\[ Net\ photosynthesis \] 3.20 g/m²/d
\[ Soil\ CO_2\ efflux \] 850 g/m²/y
\[ R_{root}\ (included\ in\ above) \] 0.8 g/m²/d
\[ Biomass\ C \] 165 Mg/ha

3a. Using the values above to calculate the following in g/m²/y:

\[ GPP \] \( 3.20 \times 365 = 1168 \)
\[ NPP \] \( (3.2-1.6) \times 365 = 584 \)
\[ Autotrophic\ respiration \] \( (0.8+0.5+0.3) \times 365 = 584 \)
\[ Heterotrophic\ respiration \] \( (850-(0.8 \times 365)) = 558 \)
\[ A\ simple\ estimate\ of\ NEP \] \( 584-558 = 26 \)

3b. Is this ecosystem accumulating or losing C? How can you tell?
Accumulating. NEP is positive
4. Label the following: GPP, $R_{\text{ecosystem}}$, C uptake, and C release. Draw a line for NEP. Is the ecosystem gaining or losing C? Why? Note the horizontal line marks an axis at 0.

GPP is the upper line
Reco is the lower dotted line. C uptake is above 0; C release is below 0. NEP is slightly negative because Reco is greater than GPP.