Questions on RBAC.

a. In the figure below $p_i$’s represent permissions and $e_i$’s represent users. Their assignments to roles in the hierarchy are shown by the dotted arrows. [10]
   i. Find $\text{assigned\_users}(r)$ and $\text{authorized\_users}(r)$ for each $r$ in the figure.
   ii. Find $\text{assigned\_permissions}(r)$ and $\text{authorized\_permissions}(r)$ for each $r$ in the figure. [10]

b. Questions on Separation of Duty constraints [10, 10, 10, 10]
   i. Let $(\{r_1, r_2, r_3, r_4\}, 3) \in \text{SSD}$, which of the following UA sets are valid:
      - $\text{UA}_1 = \{(u_1, r_1), (u_2, r_1), (u_3, r_1), (u_1, r_2), (u_4, r_2), (u_5, r_2), (u_1, r_3), (u_2, r_3), (u_3, r_3), (u_4, r_4)\}$
      - $\text{UA}_2 = \{(u_1, r_1), (u_3, r_1), (u_5, r_1), (u_1, r_2), (u_2, r_2), (u_3, r_2), (u_5, r_2), (u_2, r_3), (u_4, r_3), (u_4, r_4)\}$
      Provide reasons for your answer.
   ii. Differentiate between SSD and DSD. Suppose we have $(\{r_1, r_2, r_3, r_4\}, 3) \in \text{SSD}$ and $(\{r_1, r_2, r_3, r_4\}, 3) \in \text{DSD}$ – what are the implications of having
both of these separation of duty constraints present in a system at the same time.

iii. Can the roles Senior Administrator and Senior Engineer of the role hierarchy shown above be in separation of duty? Give reasons.

iv. Give a transformation procedure for representing the Biba’s strict integrity policy (without the third rule) using RBAC. Argue that your transformation is correct.