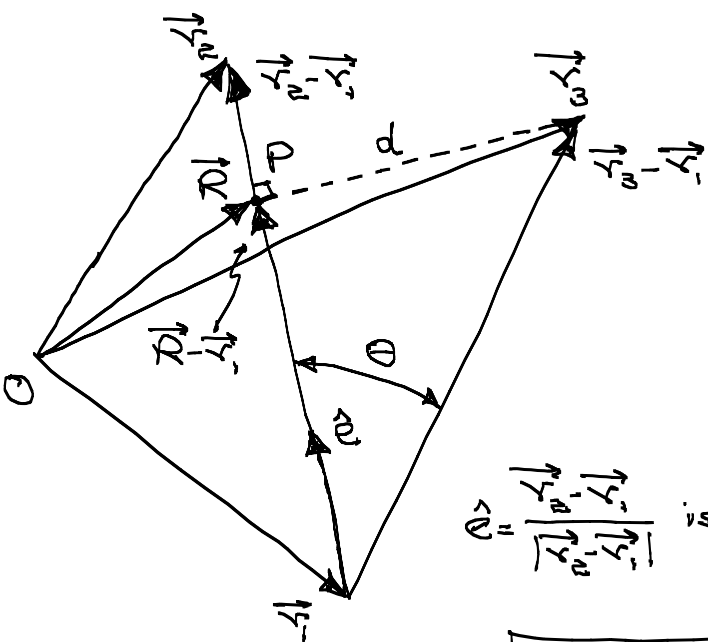
2.4



$\hat{e} = \dfrac{\vec{r}_2-\vec{r}_1}{|\vec{r}_2-\vec{r}_1|}$ is the unit vector along $\vec{r}_2-\vec{r}_1$

(a) Straight line: $\boxed{\vec{r}(s) = \vec{r}_1 + s\hat{e} = \vec{r}_1 + s\dfrac{\vec{r}_2-\vec{r}_1}{|\vec{r}_2-\vec{r}_1|}}$

(b) $d = |\vec{r}_3-\vec{r}_1|\,|\sin\theta| = |(\vec{r}_3-\vec{r}_1)\times\hat{e}|$

$$\Longrightarrow \boxed{d = \frac{|(\vec{r}_3-\vec{r}_1)\times(\vec{r}_2-\vec{r}_1)|}{|\vec{r}_2-\vec{r}_1|}}$$

When the tip of $\vec{r}_3$ is on the the line, $\vec{r}_3-\vec{r}_1$ is parallel to $\vec{r}_2-\vec{r}_1$, so the cross product vanishes and $d=0$, as it should.

(c) $\vec{R}-\vec{r}_1 = |\vec{r}_3-\vec{r}_1|\cos\theta\,\hat{e} = \underbrace{[(\vec{r}_3-\vec{r}_1)\cdot\hat{e}]\hat{e}}_{\text{projection of } \vec{r}_3-\vec{r}_1 \text{ onto } \hat{e}}$

$$\Longrightarrow \boxed{\vec{R} = \vec{r}_1 + \hat{e}\underbrace{[\hat{e}\cdot(\vec{r}_3-\vec{r}_1)]}_{s} = \vec{r}_1 + (\vec{r}_2-\vec{r}_1)\frac{(\vec{r}_2-\vec{r}_1)\cdot(\vec{r}_3-\vec{r}_1)}{|\vec{r}_2-\vec{r}_1|^2}}$$

When the tip of $\vec{r}_3$ is on the line, $\hat{e} = \dfrac{\vec{r}_3-\vec{r}_1}{|\vec{r}_3-\vec{r}_1|}$, so $\vec{R} = \vec{r}_3$, as it should.