DCM 1.22 $\|\vec{L}_{cm}\| = \|\sum_i \vec{r}_i{}' \times \vec{p}_i{}'\|$

$\leq \sum_i \|\vec{r}_i{}' \times \vec{p}_i{}'\|$ by the triangle inequality.

$$\|\vec{r}_i{}' \times \vec{p}_i{}'\| = \|\vec{r}_i{}'\| \, \|\vec{p}_i{}'\| \cdot |\sin(\text{angle})| \leq \|\vec{r}_i{}'\| \cdot \|\vec{p}_i{}'\|.$$

Thus

a) $$\|\vec{L}_{cm}\| \leq \sum_i \|\vec{r}_i{}'\| \, \|\vec{p}_i{}'\| = \sum_i \left(m_i^{\frac{1}{2}} \|\vec{r}_i{}'\|\right)\left(m_i^{1/2} \|\vec{v}_i{}'\|\right)$$

The Schwarz inequality says

$$\sum_i \lambda_i \mu_i \leq \left(\sum_i \lambda_i^2\right)^{\frac{1}{2}} \left(\sum_i \mu_i^2\right)^{\frac{1}{2}}$$

So $$\|\vec{L}_{cm}\| \leq \left(\sum_i m_i \vec{r}_i{}'^2\right)^{\frac{1}{2}} \left(\sum_i m_i \vec{v}_i{}'^2\right) = (2S)^{\frac{1}{2}} (2T_{cm})^{\frac{1}{2}}$$ or

(b) $$\boxed{\vec{L}_{cm}^2 \leq 4 S T_{cm}}$$

$\ddot{S} = 2T_{cm} + U = T_{cm} + T_{cm} + U = T_{cm} + W \Rightarrow$

$T_{cm} = \ddot{S} - W. \Rightarrow$

(c) $$\boxed{\vec{L}_{cm}^2 \leq 4S(\ddot{S} - W)}$$