$$\left(\frac{d^2\vec{r}}{dt^2}\right)_{INERTIAL} = \left(\frac{d^2\vec{r}\,'}{dt^2}\right)_{ROT} + \left(\frac{d^2\vec{R}}{dt^2}\right)_{INERTIAL} + \dot{\vec{\omega}}\times\vec{r}\,' + \vec{\omega}\times\left(\vec{\omega}\times\vec{r}\,'\right) + 2\vec{\omega}\times\vec{v}_{ROT}$$

$$I_{ij} = \sum_{\alpha} m_{\alpha}\left[\delta_{ij}\left|\vec{r}_{\alpha}\,'\right|^2 - x'_{\alpha i}\,x'_{\alpha j}\right]$$

If $\overleftrightarrow{I^{CM}}$ is the inertia tensor with respect to axes that have a COM origin, and $\overleftrightarrow{I^{new}}$ is the inertia tensor for the same object with respect to parallel axes that have a different pivot origin (that's at (ξ, η, ζ) with respect to the COM origin) are
$I_{xx}^{new} = I_{xx}^{CM} + M[\eta^2 + \zeta^2]$ and $I_{yz}^{new} = I_{yz}^{CM} - M\eta\zeta$
and you should be able to figure out other shifts by analogy.

$$\vec{\omega} = \dot{\phi}\hat{z} + \dot{\theta}\hat{e}_2 + \dot{\psi}\hat{e}_3$$

$$\Gamma_1 = \lambda_1\dot{\omega}_1 - \left(\lambda_2 - \lambda_3\right)\omega_2\omega_3$$
$$\Gamma_2 = \lambda_2\dot{\omega}_2 - \left(\lambda_3 - \lambda_1\right)\omega_3\omega_1$$

$\mathrm{T} = \frac{1}{2}MV_{COM}^2 + \frac{1}{2}\sum_i\sum_j I_{ij}^{COM}\,\omega_i\,\boldsymbol{\omega_j}$ or sometimes $\mathrm{T} = \frac{1}{2}\sum_i\sum_j I_{ij}^{pivot}\,\omega_i\,\omega_j$

The integral you did in homework was: $\int\frac{\pm\left(\ell/r^2\right)dr}{\sqrt{2\mu[E-U(r)-(\ell^2/2\mu r^2)]}}$ for a case where $U(r) = \frac{-k}{r}$. For this case, you defined $\varepsilon = \sqrt{1+\frac{2E\ell^2}{\mu k^2}}$ and $c = \frac{\ell^2}{\mu k}$, and found that you could write your result as $r(\phi) = \frac{c}{1+\varepsilon\cos\phi}$. Examining the elliptical r orbits using this result for the case of gravity, Taylor found that the short axis had halflength $\frac{c}{\sqrt{1-\varepsilon^2}}$, and that the constant in Kepler's 3rd law was $\frac{4\pi^2\mu}{k}$. We plugged c and ε into $\frac{2c}{1-\varepsilon^2}$ and got $\frac{-k}{E}$. I think results above are more handy than the form for d given in Taylor, but I'll give that answer for the distance between the center of the ellipse and its focus: $d = a\varepsilon$.

For COM origin can plug $\vec{r}_1 = -\frac{m_2}{m_1}\vec{r}_2$ or $\frac{m_1}{m_2}\vec{r}_1 = -\vec{r}_2$ into $\vec{r} = \vec{r}_1 - \vec{r}_2$

We argued

$$\sum_j \left[\frac{\partial H}{\partial q_j} dq_j + \frac{\partial H}{\partial p_j} dp_j\right] + \frac{\partial H}{\partial t} dt = \sum_j \left[p_j d\dot{q}_j + \dot{q}_j dp_j\right] - \left\{\sum_j \left[\frac{\partial \mathcal{L}}{\partial q_j} dq_j + \frac{\partial \mathcal{L}}{\partial \dot{q}_j} d\dot{q}_j\right] + \frac{\partial \mathcal{L}}{\partial t} dt\right\}$$

In phase space $\vec{\nabla} = \sum_j \left(\hat{q}_j \frac{\partial}{\partial q_j} + \hat{p}_j \frac{\partial}{\partial p}\right)$

$$drag\ coeff = \frac{f_{drag}}{.5\rho V^2 A_\perp}$$

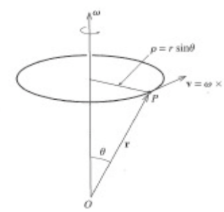
$$Re = \frac{(lengthcale)(velocity)(fluid\ density)}{viscosity}$$

$$\vec{a} = (\ddot{r} - r\dot{\phi}^2)\hat{e}_r + (r\ddot{\phi} + 2\dot{r}\dot{\phi})\hat{e}_\phi)$$

$$\vec{a} = (\ddot{r} - r\dot{\phi}^2)\hat{e}_r + (r\ddot{\phi} + 2\dot{r}\dot{\phi})\hat{e}_\phi) + \ddot{z}\hat{e}_z$$

$$\vec{a} = (\ddot{r} - r\dot{\phi}^2 \sin^2\theta - r\dot{\theta}^2)\hat{e}_r + (2\dot{r}\dot{\theta} + r\ddot{\theta} - r\dot{\phi}^2 \sin\theta\cos\theta)\hat{e}_\theta + \frac{1}{r\sin\theta}\frac{d}{dt}\left(r^2\dot{\phi}\sin^2\theta\right)\hat{e}_\phi$$

$$\frac{d\vec{L}}{dt} = \vec{R}_{COM} \times M\ddot{\vec{R}}_{COM} + \frac{d}{dt}\left[\sum \vec{r'}_\alpha \times m_\alpha \dot{\vec{r'}}_\alpha\right]$$



$$\vec{\mathbf{v}}_{\substack{bit\\wrt\\obs}} = \vec{\mathbf{v}}_{\substack{C\\wrt\\obs}} + \vec{\mathbf{v}}_{\substack{bit\\wrt\\C}}$$

$$\vec{v}_{\substack{bit\\wrt\\O}} = \vec{\omega} \times \vec{r}_{\substack{bit\\wrt\\O}}$$

$$\vec{a}_{\substack{bit\\wrt\\obs}} = \vec{a}_{\substack{O\\wrt\\obs}} + \dot{\vec{\omega}} \times \vec{r}_{\substack{bit\\wrt\\O}} + \vec{\omega} \times \left[\vec{v}_{\substack{bit\\wrt\\O}} = \vec{\omega} \times \vec{r}_{\substack{bit\\wrt\\O}}\right]$$

$$I_Z^{NEW} = I_Z^{CM} + M(X_{NEW}^2 + Y_{NEW}^2)$$

$dV = \rho d\phi\, d\rho\, dz$ $\quad$ $dV = r^2 sin\theta d\phi\, dr\, d\theta$ $\quad$ $\delta_n \rightarrow 4.6692016 \ldots$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x + iy = \sqrt{x^2 + y^2}\exp(i\mathrm{Arctan}(y/x))$$

I made add some moment of inertia values here but also know how to calculate those.