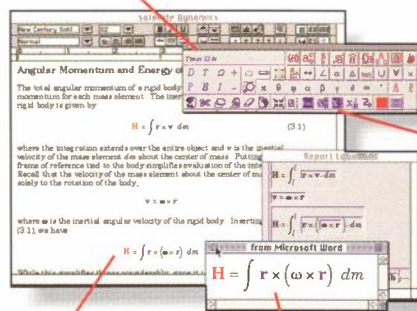


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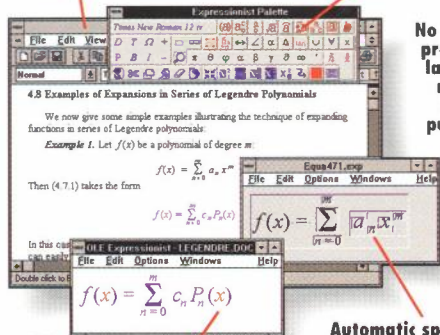
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**System Requirements for the Macintosh:**  
One (1) MB of RAM required. Runs on Mac Plus and above, including Quadras. System 6, 7, A/UX, 32-bit, Virtual Memory Compatible.

**System Requirements for Microsoft Windows:**  
Two (2) MB of RAM required. MS Windows 3.X. A mouse is recommended for ease of use.

## Angular Momentum and Energy of Rigid Bodies

The total angular momentum of a rigid body is the sum of the angular momentum for each mass element. The inertial angular momentum of a rigid body is given by

$$\mathbf{H} = \int \mathbf{r} \times \mathbf{v} \, dm \quad (3.1)$$

where the integration extends over the entire object and  $\mathbf{v}$  is the inertial velocity of the mass element  $dm$  about the center of mass. Putting (3.1) into a frame of reference tied to the body simplifies evaluation of the integral. Recall that the velocity of the mass element about the center of mass is due solely to the rotation of the body,

$$\mathbf{v} = \boldsymbol{\omega} \times \mathbf{r} \quad (3.2)$$

where  $\boldsymbol{\omega}$  is the inertial angular velocity of the rigid body. Inserting (3.2) into (3.1), we have

$$\mathbf{H} = \int \mathbf{r} \times (\boldsymbol{\omega} \times \mathbf{r}) \, dm \quad (3.3)$$

While this simplifies things considerably, since it is desirable to remove the angular-velocity vector from within the integral (3.3). This separates (3.3) into a portion depending on the mass distribution within the body and a portion which gives its rotational velocity. The mass integrals need only be evaluated once and for all time. Writing the vectors  $\mathbf{r}$  and  $\boldsymbol{\omega}$  in their body-frame components:

$$\mathbf{r} = x \mathbf{b}_1 + y \mathbf{b}_2 + z \mathbf{b}_3 \quad (3.4)$$

$$\boldsymbol{\omega} = \omega_1 \mathbf{b}_1 + \omega_2 \mathbf{b}_2 + \omega_3 \mathbf{b}_3 \quad (3.5)$$

After doing a bit of algebraic simplification, the expression for the angular momentum becomes

$$\mathbf{H} = \begin{bmatrix} \mathbf{b}_1 \\ \mathbf{b}_2 \\ \mathbf{b}_3 \end{bmatrix} \begin{bmatrix} \omega_1 (y^2 + z^2) - \omega_2 xy - \omega_3 xz \\ -\omega_1 yx + \omega_2 (x^2 + z^2) - \omega_3 yz \\ -\omega_1 zx - \omega_2 zy + \omega_3 (x^2 + y^2) \end{bmatrix} dm \quad (3.6)$$

\* Windows version supports Microsoft Object Linking and embedding (OLE).

Macintosh version supports System 7 Edit Graphic Object (EGO) Apple event programs.

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