66. Since we will be taking the vector cross product in the course of our calculations, below, we note first that when the two vectors in a cross product $\vec{A} \times \vec{B}$ are in the xy plane, we have $\vec{A} = A_x\hat{\mathrm{i}} + A_y\hat{\mathrm{j}}$ and $\vec{B} = B_x\hat{\mathrm{i}} + B_y\hat{\mathrm{j}}$, and Eq. 3-30 leads to

$$\vec{A} \times \vec{B} = (A_xB_y - A_yB_x)\,\hat{\mathrm{k}} \;.$$

Now, we choose coordinates centered on point O, with $+x$ rightwards and $+y$ upwards. In unit-vector notation, the initial position of the particle, then, is $\vec{r}_0 = s\,\hat{\mathrm{i}}$ and its later position (halfway to the ground) is $\vec{r} = s\,\hat{\mathrm{i}} - \frac{1}{2}h\,\hat{\mathrm{j}}$. Using either the free-fall equations of Ch. 2 or the energy techniques of Ch. 8, we find the speed at its later position to be $v = \sqrt{2g|\Delta y|} = \sqrt{gh}$. Its momentum there is $\vec{p} = -M\sqrt{gh}\,\hat{\mathrm{j}}$. We find the angular momentum using Eq. 12-18 and our observation, above, about the cross product of two vectors in the xy plane.

$$\vec{\ell} = \vec{r} \times \vec{p} = -sM\sqrt{gh}\;\hat{\mathrm{k}}$$

Therefore, its magnitude is $|\vec{\ell}| = sM\sqrt{gh}$.