

Rotational energy, rolling and angular momentum

AP Physics 1 (algebra-based) · Lab answers

The model answers use the sample data above. Your own rotational inertia will differ, but the angular momentum before and after should agree closely, while the kinetic energy increases.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 6

Question 1 Angular speeds

Arms out: $\omega = 18.85 \div 17.2 = \mathbf{1.10 \text{ rad/s}}$. Arms in: $\omega = 18.85 \div 10.0 = \mathbf{1.89 \text{ rad/s}}$ (3 turns = $6\pi = 18.85 \text{ rad}$).

Question 2 Rotational inertia of the weights

Out: $2 \times 1.5 \times (0.70)^2 = \mathbf{1.47 \text{ kg m}^2}$. In: $2 \times 1.5 \times (0.25)^2 = \mathbf{0.19 \text{ kg m}^2}$ (0.1875).

Question 3 Rotational inertia of student and chair

$(I_0 + 1.47) \times 1.096 = (I_0 + 0.1875) \times 1.885$. Expanding: $1.096I_0 + 1.611 = 1.885I_0 + 0.353$, so $0.789I_0 = 1.258$ and $I_0 = \mathbf{1.6 \text{ kg m}^2}$.

Question 4 Checking the conservation law

Out: $L = (1.6 + 1.47) \times 1.096 = 3.07 \times 1.096 = \mathbf{3.36 \text{ kg m}^2/\text{s}}$. In: $L = (1.6 + 0.19) \times 1.885 = 1.79 \times 1.885 = \mathbf{3.37 \text{ kg m}^2/\text{s}}$. The difference is about 0.3 %, so L is conserved to within the precision of the measurements.

Question 5 Kinetic energy change

Out: $K = \frac{1}{2} \times 3.07 \times (1.096)^2 = \mathbf{1.84 \text{ J}}$. In: $K = \frac{1}{2} \times 1.79 \times (1.885)^2 = \mathbf{3.18 \text{ J}}$. K increases by about 1.3 J because the student does work pulling the weights inwards; L , not K , is conserved.

Question 6 Uncertainty

Range = $17.4 - 17.0 = 0.4 \text{ s}$, so uncertainty = 0.2 s , which is $0.2 \div 17.2 = \mathbf{1.2 \%}$. Since $\omega \propto 1/t$, ω has the same percentage uncertainty, about 0.013 rad/s .

Question 7 Friction and other errors

Friction in the bearing exerts an external torque, which slowly reduces L , so ω falls between the two measurements and the calculated I_0 is distorted. The arms and the weights are not point masses at a single radius, so the weights' I is slightly different from $2mr^2$. **Both make the conservation check slightly imperfect.**

Question 8 Making the test fairer

Choose a ball-bearing turntable so that bearing friction is smaller, and time more turns for each reading while filming from above, so the angle against time is known more exactly.

These reduce friction and random timing error.