

# AP Quiz: Conservation Laws

Full Name, Period, AP/Honors:

**Select 4 questions to complete.** Only honors students may select the honors questions. AP students must select from the remaining questions. If more than 4 questions are completed and it is not clear which should be graded, the worst 4 will be chosen.

## 1 So many ways to stab myself in the foot!

1. An ice skater begins to spin with her arms straight out. After some time, she pulls her arms in close to her torso. What happens to her angular speed? (The ice is assumed to be frictionless and unable to apply a force to her.)

A. It decreases because kinetic energy is conserved and more energy is now in her torso.

B. It decreases because angular momentum is conserved, and more angular momentum is now in her torso

C. It increases because kinetic energy is conserved and kinetic energy transferred from her arms to her torso.

D. It increases because angular momentum is conserved and the moment of inertia decreased.

E. It stays the same because both kinetic energy and angular momentum are conserved.

2. You have a solid disk with mass  $M$  and radius  $R$  that is mounted on a frictionless axle with negligible radius. You apply a constant force  $F$  tangent to the edge of the disk and keep applying the force until the disk does exactly 1 full revolution. What will be the final angular speed of the disk?

A.  $\omega = \frac{4\pi F}{MR}$

B.  $\omega = \sqrt{\frac{8\pi F}{MR}}$

C.  $\omega = \frac{4F}{MR}$

D.  $\omega = \sqrt{\frac{2F}{MR}}$

E.  $\omega = \pi\sqrt{\frac{5F}{MR^2}}$

3. Which of these definitions of  $x$  and  $y$  could you graph so that the slope of the line would represent the constant  $A$  in

$$z^2 = e^{At}$$

A.  $y : (\ln z)^2$  against  $x : t$

B.  $y : 2 \ln z$  against  $x : t$

C.  $y : At$  against  $x : z^2$

D.  $y : e^{2z}$  against  $x : e^{At}$

E.  $y : z^2$  against  $x : e^t$

4. (**Honors only**) A rod that is free to rotate and translate but is initially static is struck at its end with a ball (mass  $m$ ) that had an initial velocity  $v_b$ . The ball recoils with a speed  $-v_{ball}$ . What will be the final momentum of the rod?

A.  $p = -2mv_b$

B.  $p = 2mv_b$

C.  $p = mv_b$

D.  $p = \frac{mv_b}{3}$

E.  $p = \sqrt{2mv_b + v_b^2}$

5. (**Honors only**) Which of these definitions of  $x$  and  $y$  could you graph so that the slope of the line would represent the constant  $A$  in

$$z = At^3$$

A.  $y : z$  against  $x : t$

B.  $y : z$  against  $x : t^{1/3}$

C.  $y : At^2$  against  $x : z$

D.  $y : z$  against  $x : t^3$

E.  $y : z^2$  against  $x : t^{5/2}$

## 2 Freedom to respond as indicated

1. A vertically oriented rod that is free to rotate and translate but is initially static is struck at its end with a ball (mass  $m$ ) that had an initial horizontal velocity  $v_b\hat{x}$ . The ball recoils with a velocity nearly  $-v_b\hat{x}$ . The rod ends up with a linear speed  $v$  and an angular speed  $\omega$ . What was the length of the rod? The moment of inertia of a rod with total length  $R$  is  $\frac{1}{12}MR^2$ .

2. An object with mass  $M$  and radius  $R$  rolls without slipping down a hill with height  $h$  and ends up with a final translational speed of  $v = \sqrt{\frac{3}{2}gh}$ . What is the moment of inertia of the object?

3. Two disks have their centers on the same axis. The disks initially have

- Disk 1
  - Mass  $M$
  - Radius  $R$
  - Angular velocity  $\omega$  clockwise
- Disk 2
  - Mass  $M$
  - Radius  $R/2$
  - Angular velocity  $\omega$  counterclockwise

After the two disks come together and begin to rotate as a single object, what will be the final angular velocity?