This print-out should have 15 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering. The due time is Central time.

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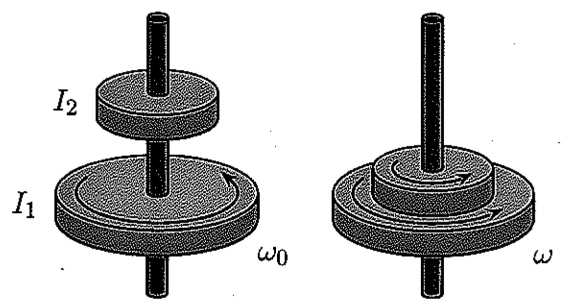
**Serway CP 08 55 D**

11:10, trigonometry, numeric, > 1 min, wording-variable.

**001**

A cylinder with moment of inertia 30 kg m$^2$ rotates with angular velocity 5 rad/s on a frictionless vertical axle. A second cylinder, with moment of inertia 35 kg m$^2$, initially not rotating, drops onto the first cylinder and remains in contact. Since the surfaces are rough, the two eventually reach the same angular velocity.




Calculate the final angular velocity. Answer in units of rad/s.

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**002**

Show that energy is lost in this situation by calculating the ratio of the final to the initial kinetic energy.

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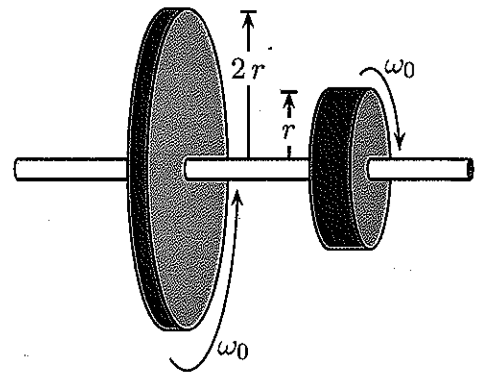
**Tipler PSE5 10 58**

11:10, trigonometry, multiple choice, > 1 min, fixed.

**003**

Two disks of identical mass but different radii ($r$ and $2r$) are spinning on frictionless bearings at the same angular speed $\omega_0$ but in opposite directions. The two disks are brought slowly together. The resulting frictional force between the surfaces eventually brings them to a common angular velocity.




What is the magnitude of that final angular velocity in terms of $\omega_0$?

1. $\omega_f = \dfrac{3}{5}\,\omega_0$
2. $\omega_f = \dfrac{1}{2}\,\omega_0$
3. $\omega_f = \dfrac{1}{3}\,\omega_0$
4. $\omega_f = \dfrac{2}{3}\,\omega_0$
5. $\omega_f = \dfrac{1}{4}\,\omega_0$
6. $\omega_f = \dfrac{3}{4}\,\omega_0$
7. $\omega_f = \dfrac{1}{5}\,\omega_0$
8. $\omega_f = \dfrac{2}{5}\,\omega_0$
9. $\omega_f = \dfrac{4}{5}\,\omega_0$

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**Supernova Explosion**

11:10, trigonometry, numeric, > 1 min, normal.

**004**

A star of radius 10000 km rotates about its axis with a period of 30 days. The star undergoes a supernova explosion, whereby its core collapses into a neutron star of radius 3 km.

Estimate the period of the neutron star (assume the mass remains constant). Answer in units of s.

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**Child on a Merrygoround**

11:10, trigonometry, multiple choice, > 1 min, fixed.

**005**

A child is standing on the edge of a merry-go-round that is rotating with frequency f. The child then walks towards the center of the merry-go-round.

For the system consisting of the child plus the merry-go-round, what remains constant as the child walks towards the center? (neglect friction in the bearing)

**1.** mechanical energy and angular momentum

**2.** neither mechanical energy nor angular momentum

**3.** only angular momentum

**4.** only mechanical energy

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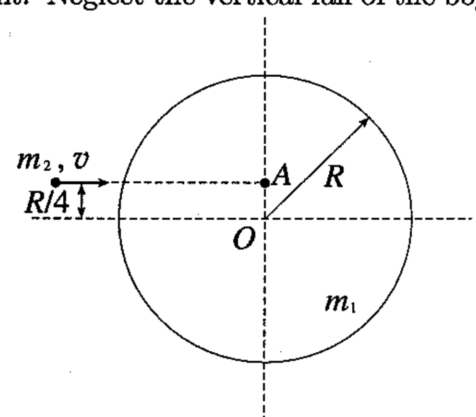
### Spinning Merry Go Round

11:10, trigonometry, numeric, > 1 min, normal.

**006**

Consider a freely spinning merry-go-round, which can be treated as a uniform disc of radius $R$ and mass $m_1$ rotating about a vertical axis through its center. Initially the merry-go-round is at rest. A boy of mass $m_2$ jumps with a horizontal speed $v$, landing at A, which is a distance $\frac{R}{4}$ from the center.

*Hint:* Neglect the vertical fall of the boy.




As the boy is approaching the merry-go-round, what is the magnitude of his initial angular momentum with respect to the center of the merry-go-round?

**1.** $L_i = m_1\, v\, \frac{R}{4}$

**2.** $L_i = m_1\, v\, \frac{R}{2}$

**3.** $L_i = m_1\, v\, \frac{3\,R}{4}$

**4.** $L_i = m_1\, v\, R$

**5.** $L_i = m_2\, v\, \frac{R}{2}$

**6.** $L_i = m_2\, v\, \frac{R}{4}$

**7.** $L_i = m_2\, v\, \frac{3\,R}{4}$

**8.** $L_i = m_2\, v\, R$

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**007**

Consider the case where the mass of the boy is the same as the mass of the merry-go-round; *i.e.*, $m_1 = m_2 = m = 40$ kg. The radius of the merry-go-round is $R = 10$ m. The initial velocity of the boy is $v = 5$ m/s.

*Hint:* Treat the boy and the merry-go-round together as an isolated system.

Determine the final angular velocity of the merry-go-round in radian/sec. Answer in units of radian/sec.

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### Child on a MerryGoRound 02

11:10, trigonometry, numeric, > 1 min, normal.

**008**

A child of mass 52 kg sits on the edge of a merry-go-round with radius 1.8 m and moment of inertia 136.469 kg m$^2$. The merry-go-round rotates with an angular velocity of 2.1 rad/s.

What radial force does the child have to exert to stay on the merry-go-round? Answer in units of N.

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**009**

The child then walks towards the center of the merry-go-round and stops at a distance 0.63 m from the center. Now what is the angular velocity of the merry-go-round? Answer in units of rad/s.

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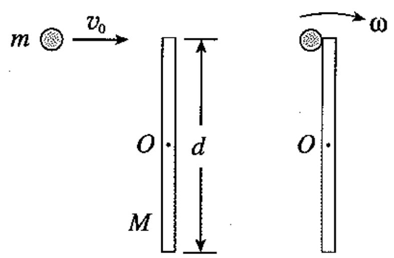
**Projectile Sticks to a Rod**

11:10, trigonometry, numeric, > 1 min, normal.

**010**

A projectile of mass $m = 1$ kg moves to the right with speed $v_0 = 20$ m/s. The projectile strikes and sticks to the end of a stationary rod of mass $M = 5$ kg and length $d = 2$ m that is pivoted about a frictionless axle through its center.




Find the angular speed of the system right after the collision. Answer in units of rad/s.

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**011**

How much kinetic energy is lost in the collision relative to the initial kinetic energy? (Determine the ratio of the kinetic energy lost to the initial kinetic energy)

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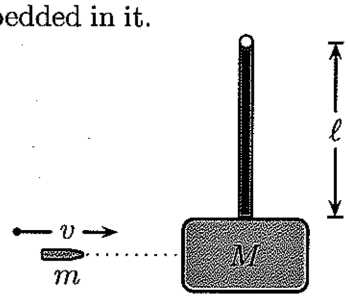
**Bullet Rotates a Rod 01**

11:10, trigonometry, multiple choice, > 1 min, fixed.

**012**

A wooden block of mass $M$ hangs from a rigid rod of length $\ell$ having negligible mass. The rod is pivoted at its upper end. A bullet of mass $m$ traveling horizontally and normal to the rod with speed $v$ hits the block and gets embedded in it.




What is the angular momentum $L$ of the block-bullet system, with respect to the pivot point immediately after the collision?

1. $L = m\,v\,\ell$
2. $L = (M - m)\,v\,\ell$
3. $L = \left(\dfrac{M\,m}{M + m}\right) v\,\ell$
4. $L = (m + M)\,v\,\ell$
5. $L = M\,v\,\ell$

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**013**

What is the fraction $\dfrac{K_f}{K_i}$ (the final kinetic energy compared to the initial kinetic energy) in the collision?

1. $\dfrac{K_f}{K_i} = \dfrac{m}{m + M}$
2. $\dfrac{K_f}{K_i} = \dfrac{2\,m}{m + M}$
3. $\dfrac{K_f}{K_i} = \dfrac{m}{M - m}$
4. $\dfrac{K_f}{K_i} = \dfrac{M}{M + m}$
5. $\dfrac{K_f}{K_i} = \dfrac{M}{M - m}$

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**Clay Rotates a Rod 01**

11:10, trigonometry, multiple choice, > 1 min, fixed.

**014**

A uniform rod, supported and pivoted at its midpoint, but initially at rest, has a mass $2\,m$ and a length $\ell$. A piece of clay with mass $m$ and velocity $v$ hits one end of the rod, gets stuck and causes the clay-rod system to spin about the pivot point $O$ at the center of the rod in a horizontal plane.

Viewed from above the scheme is

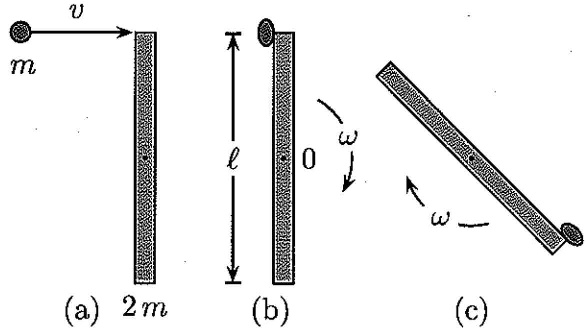


**Figure:** The piece of clay and rod:
(a) before they collide,
(b) at the time of the collision, and
(c) after they collide.

After the collisions the clay-rod system has an angular velocity $\omega$ about the pivot.

With respect to the pivot point $O$, what is the magnitude of the initial angular momentum $L_i$ of the piece of clay and the final moment of inertia $I_f$ of the clay-rod system?

1. $L_i = m\,v\,\ell\,,\qquad I_f = \frac{5}{12}\,m\,\ell^2$
2. $L_i = m\,v\,\frac{\ell}{2}\,,\qquad I_f = \frac{8}{12}\,m\,\ell^2$
3. $L_i = m\,v\,\ell\,,\qquad I_f = \frac{3}{12}\,m\,\ell^2$
4. $L_i = m\,v\,\ell\,,\qquad I_f = \frac{8}{12}\,m\,\ell^2$
5. $L_i = m\,v\,\ell\,,\qquad I_f = \frac{4}{12}\,m\,\ell^2$
6. $L_i = m\,v\,\frac{\ell}{2}\,,\qquad I_f = \frac{5}{12}\,m\,\ell^2$
7. $L_i = m\,v\,\frac{\ell}{2}\,,\qquad I_f = \frac{4}{12}\,m\,\ell^2$
8. $L_i = m\,v\,\frac{\ell}{2}\,,\qquad I_f = \frac{7}{12}\,m\,\ell^2$

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**015**

The final angular speed $\omega_f$ of the rod-clay system is

1. $\omega_f = \frac{6}{5}\,v\,.$
2. $\omega_f = \frac{12}{5}\,\frac{v}{\ell}\,.$
3. $\omega_f = \frac{6}{5}\,\frac{v}{\ell}\,.$
4. $\omega_f = \frac{4}{6}\,v\,.$
5. $\omega_f = \frac{12}{7}\,\frac{v}{\ell}\,.$
6. $\omega_f = \frac{5}{6}\,\frac{v}{\ell}\,.$
7. $\omega_f = \frac{6}{2}\,\frac{v}{\ell}\,.$
8. $\omega_f = \frac{5}{12}\,\frac{v}{\ell}\,.$
9. $\omega_f = \frac{12}{7}\,v\,.$
10. $\omega_f = \frac{3}{5}\,\frac{v}{\ell}\,.$