

This print-out should have 10 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

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### Torque in 3D

**001** (part 1 of 3) 10.0 points

A force  $\vec{F} = F_x \hat{i} + F_y \hat{j} + F_z \hat{k}$  acts on a particle located at  $\vec{X} = (x, y, z)$ . Given  $F_x = -75.6$  N,  $F_y = 53.5$  N,  $F_z = -80.8$  N,  $x = 3.68$  m,  $y = -6.15$  m and  $z = 8.35$  m, calculate the three components of the torque vector  $\vec{\tau} = \tau_x \hat{i} + \tau_y \hat{j} + \tau_z \hat{k}$ .

First, calculate the  $\tau_x$  component.

Correct answer: 50.195 N m.

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**002** (part 2 of 3) 10.0 points

Second, calculate the  $\tau_y$  component.

Correct answer: -333.916 N m.

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**003** (part 3 of 3) 10.0 points

Finally, calculate the  $\tau_z$  component.

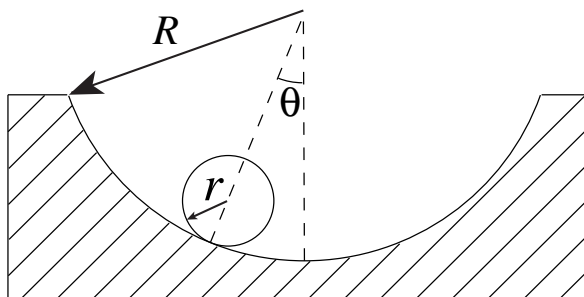
Correct answer: -268.06 N m.

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### Sphere in Hemispherical Bowl

**004** (part 1 of 3) 10.0 points

A uniform solid sphere ( $I = \frac{2}{5} m r^2$ ) of mass 1.3 kg and radius  $r = 0.305$  m, is placed on the inside surface of a hemispherical bowl of radius  $R = 1.65$  m. The sphere is released from rest at an angle  $\theta = 39.1^\circ$  from the vertical and rolls without slipping (see the figure).



The acceleration of gravity is  $9.8$  m/s<sup>2</sup>. How much potential energy has the sphere lost when it reaches the bottom of the bowl?

Correct answer: 3.83751 J.

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**005** (part 2 of 3) 10.0 points

What is the translational velocity of the sphere when it reaches the bottom of the bowl?

Correct answer: 2.05355 m/s.

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**006** (part 3 of 3) 10.0 points

What is the angular velocity of the sphere when it reaches the bottom of the bowl?

Correct answer: 6.73294 rad/s.

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### Supernova Explosion

**007** 10.0 points

A star of radius  $8.4 \times 10^5$  km rotates about its axis with a period of 20 days. The star undergoes a supernova explosion, whereby its core collapses into a neutron star of radius 19 km.

Estimate the period of the neutron star (assume the mass remains constant).

Correct answer: 0.000884082 s.

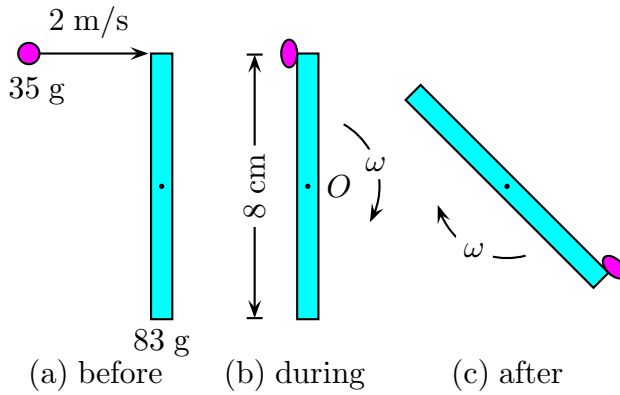
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### Clay Rotates a Rod 02

**008** (part 1 of 3) 10.0 points

A uniform rod, supported and pivoted at its midpoint, but initially at rest, has a mass of 83 g and a length 8 cm. A piece of clay with mass 35 g and velocity 2 m/s hits the very top 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



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 clay-rod system?

Correct answer: 0.0028 kg m<sup>2</sup>/s.

**009** (part 2 of 3) 10.0 points

With respect to the pivot point  $O$ , what is the final moment of inertia  $I_f$  of the clay-rod system?

Correct answer: 0.000100267 kg m<sup>2</sup>.

**010** (part 3 of 3) 10.0 points

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

Correct answer: 27.9255 rad/s.