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

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 τ_x component.

Correct answer: 50.195 N m.

002 (part 2 of 3) 10.0 points

Second, calculate the τ_y component.

Correct answer: −333.916 N m.

003 (part 3 of 3) 10.0 points

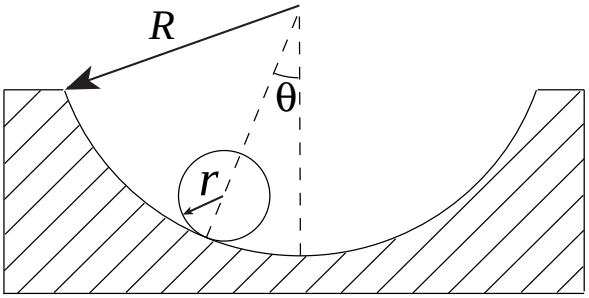
Finally, calculate the τ_z component.

Correct answer: −268.06 N m.

Sphere in Hemispherical Bowl

004 (part 1 of 3) 10.0 points

A uniform solid sphere $\left(I = \frac{2}{5}\, m\, r^2\right)$ 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^2. How much potential energy has the sphere lost when it reaches the bottom of the bowl?

Correct answer: 3.83751 J.

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.

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.

Supernova Explosion

007 10.0 points

A star of radius 8.4×10^5 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).

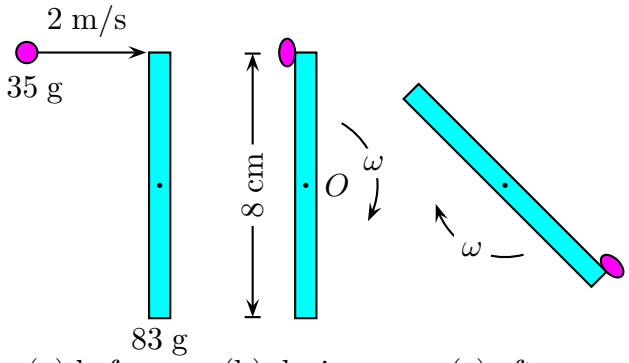
Correct answer: 0.000884082 s.

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



(a) before (b) during (c) after

After the collisions the clay-rod system has an angular velocity ω 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^2/s.

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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^2.

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010 (part 3 of 3) 10.0 points

The final angular speed ω_f of the clay-rod system is

Correct answer: 27.9255 rad/s.