Quiz 4

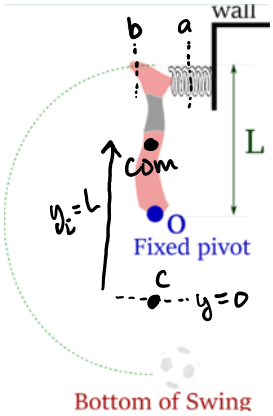
Thursday, January 28, 2021 10:07 AM

After studying the motion of a humans leg while kicking a soccer ball, Benny decided to construct a mechanical device to mimic this kicking motion. The model consists of an artificial leg of mass **M** = 12.0 kg. The leg compresses an ideal spring by 0.200 meters before the leg is released from rest. The spring has a spring constant of 7000 N/m. You can treat the leg as a thin rod with a length of **L** = 1.00 meters and a moment of inertia of 1/3 **M L**^{2} about the pivot point "**o**" shown below. For all parts of this problem, ignore the collision of the foot with the soccer ball; Benny is just testing the swinging motion without using a soccer ball at the bottom.

(a) Consider a system consisting of the leg, the spring, and the Earth. Using relevant physics concepts we have discussed this term, explain the energy transformations occurring within this system as the leg swings down to the bottom of the swing.

(b) How much rotational kinetic energy does the leg have when it reaches the bottom of its swing (i.e. after 180 degrees of rotation from the initial vertical orientation)? Hint: The center of mass of the leg is located at the center of the leg; what vertical distance does the center of mass of the leg move through from the top of the swing to the bottom of the swing?

(c) What is the angular velocity of the leg at the bottom of the swing? Hint: Spring potential energy is equal to (0.5 **k x**^{2}).



(a) a - compressed spring, b - uncompressed spring, c - bottom

EFO (leg, spring, Earth)

	a	b	c
U^s	•		
U^g	•		•
K_{rot}			•

(b) $\Sigma E_i + W_{nc}^{\nearrow 0} = \Sigma E_f$, initial = a, final = c

$U_i^s + U_i^g + K_{rot_i}^{\nearrow 0} = U_f^{\nearrow 0} + U_f^{g\nearrow 0} + K_{rot_f}$

$\frac{1}{2} k x_a^2 + m g y_a = K_{rot,c} = 257.6\ J$

(c) $K_{rot,c} = \frac{1}{2} I \omega_c^2 = \frac{1}{2}\left[\frac{1}{3} M L^2\right] \omega_c^2$, $\omega_c = \left[\frac{6 K_{rot,c}}{M L^2}\right]^{1/2} = 11.3 \frac{rad}{s}$

Rubric

(a) 1.5 points

(b)

Problem orientation	**Solution exploration**	**Solution execution**	**Solution evaluation**
1 pts - physical representation 1 pt - potential energy eqs.	1.5 pts - conservation of energy eq.	1.5 pts - application of COE	0.5 pts - Correct answer and units

(c)

Problem orientation	**Solution exploration**	**Solution execution**	**Solution evaluation**
0.5 pts - rotational KE eq 0.5 pts - moment I eq		1.5 pts - solving for omega	0.5 pts - Correct answer and units