#26 Equations of Angular Motion Post-class

Due: 11:00am on Wednesday, October 24, 2012

Note: You will receive no credit for late submissions. To learn more, read your instructor's Grading Policy

Exercise 9.33

While riding a multispeed bicycle, the rider can select the radius of the rear sprocket that is fixed to the rear axle. The front sprocket of a bicycle has radius 11.0cm .

Part A

If the angular speed of the front sprocket is 0.600$\mathrm{rev/s}$, what is the radius of the rear sprocket for which the tangential speed of a point on the rim of the rear wheel will be 6.00$\mathrm{m/s}$? The rear wheel has radius 0.350m .

ANSWER:

r = 2.42×10^{-2} m

Correct

Exercise 9.24: Ultracentrifuge

Part A

Find the required angular speed (in $\mathrm{rev/min}$) of an ultracentrifuge for the radial acceleration of a point 2.50 cm from the axis to equal 400000*g* (that is, 400000 times the acceleration due to gravity).

ANSWER:

ω = 1.20×10^{5} $\mathrm{rev/min}$

Correct

Weight and Wheel

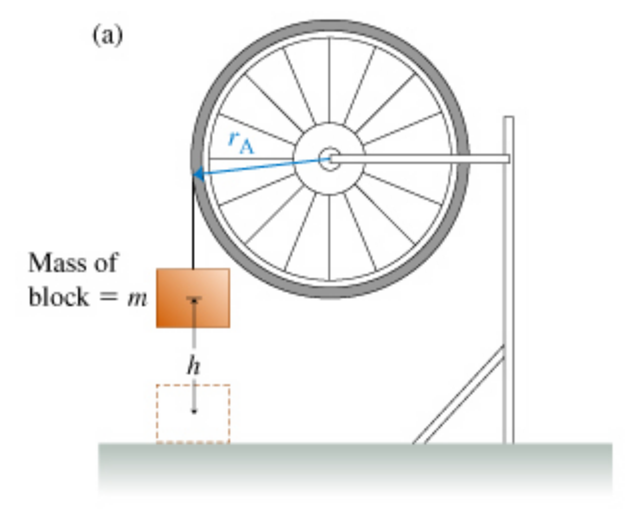
Consider a bicycle wheel that initially is not rotating. A block of mass m is attached to the wheel and is allowed to fall a distance h. Assume that the wheel has a moment of inertia I about its rotation axis.

Part A

Consider the case that the string tied to the block is attached to the outside of the wheel, at a radius r_A

. Find ω_A, the angular speed of the wheel after the block has fallen a distance h, for this case.

Express ω_A in terms of m, g, h, r_A, and I.



Hint 1. How to approach this problem

The most straightforward way to solve this problem is to use conservation of mechanical energy. The total initial energy of the system is equal to the total final energy of the system (where the system consists of the wheel and the block). In other words,

$$E_i = E_{bf} + E_{wf}.$$

Where $E_{\rm i}$ is the initial energy of the system, E_{\rm bf} is the final energy of the block and $E_{\rm wf}$ is the final energy of the wheel.

Hint 2. Initial energy of the system

Initially, the wheel is not rotating. The initial energy of the system consists of the gravitational potential energy stored in the block, since it is not moving either. Supposing that the gravitiational potential energy of the block is zero at "ground level," find the initial energy of the system.

ANSWER:

$E_{\rm i}$ = mgh

Hint 3. Final energy of block

Find the final energy of the block.

Express the final energy of the block in terms of given quantities (excluding h) and the unknown final angular velocity of the wheel, ω_A.

Hint 1. Final velocity of the block

Find $v_{\rm f}$, the magnitude of the final velocity of the block.

Express the velocity in terms of r_A and the final angular velocity of the wheel, ω_A.

ANSWER:

$v_{\rm f}$ = r_A*omega_A

ANSWER:

E_bf = $\frac{1}{2}m\left(r_A\omega_A\right)^2$

Hint 4. Final energy of wheel

Find the final kinetic energy of the wheel.

Express your answer in terms of I (the wheel's moment of inertia) and ω_A.

ANSWER:

E_{wf} = $\frac{1}{2}I{\omega_A}^2$

ANSWER:

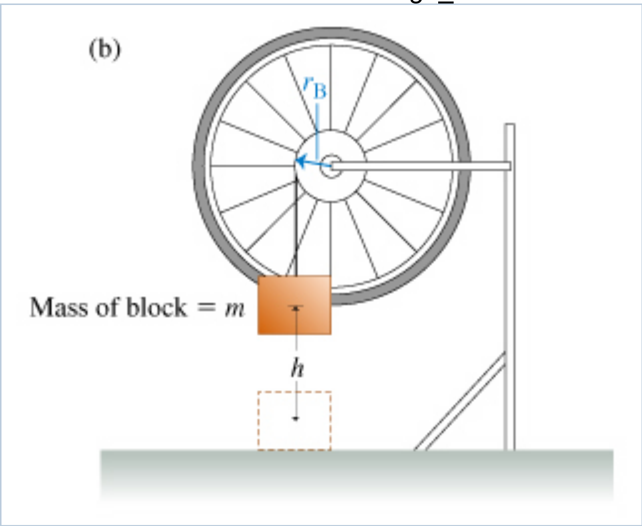
ω_A = $\sqrt{\frac{2mgh}{m{r_A}^2+I}}$

Correct

Part B

Now consider the case that the string tied to the block is wrapped around a smaller inside axle of the wheel of radius r_B . Find omega_B, the angular speed of the wheel after the block has fallen a distance h, for this case.

Express omega_B in terms of m, g, h, r_B, and I.



Hint 1. Similarity to previous part

The derivation of omega_B is exactly the same as the derivation for ω_A, using r_B instead of r_A.

ANSWER:

omega_B = $\sqrt{\frac{2mgh}{m{r_B}^2+I}}$

Correct

Part C

Which of the following describes the relationship between ω_A and omega_B?

Hint 1. How to approach this question

To figure out which angular velocity is greater (ω_A or omega_B), you only need to consider the radius dependence of the expression for ω. Ignoring all of the other parameters, you should have found that ω goes as 1/radius (where "radius" refers to where the string is attached, which is not necessarily the outer radius of the wheel). The problem then reduces to figuring out which is greater, $1/r_A$ or $1/r_B$.

ANSWER:

- $\omega_A > \omega_B$
- $\omega_B > \omega_A$
- $\omega_A = \omega_B$

Correct

This is related to why gears are found on the inside rather than the outside of a wheel.

Score Summary:

Your score on this assignment is 93.2%.
You received 27.97 out of a possible total of 30 points.