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1. (50 POINTS) A 0.145 - kg ball is thrown upward with speed $v_1 =$ 16.0 m/s. At a certain vertical height H, the ball has speed $v_2 = 2.00$ m/s. As it rises to height H, the force of air friction does work of *magnitude* 4.00 J on the ball.

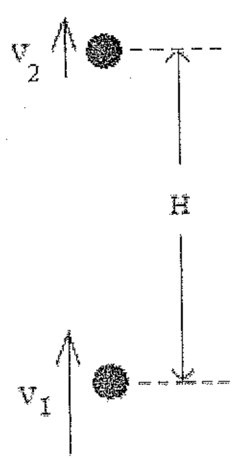
(a) (8) What is the direction of the air friction force on the ball, up or down?

(b) (7) Is the work done by the air friction force positive or negative? Explain briefly.

(c) (10) Is the work done by the gravitational force on the ball positive or negative? Explain briefly.

(d) (20) What is the height H? For full credit you must use either the work energy theorem or conservation of energy in your solution.

(e) (5) Assume the air friction force is constant. In parts (a) and (b), you addressed the direction of the friction force. In this part, find the *magnitude* f_k of the constant force of air resistance exerted on the ball during its upward motion.



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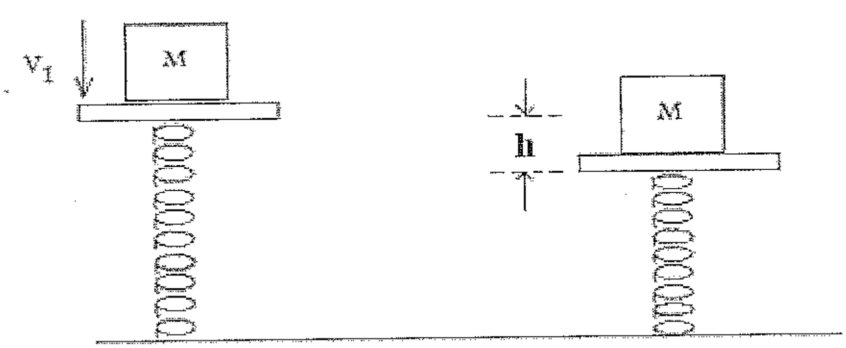
2. (50 POINTS) A block of mass M = 1.000 kg has been released from a position above a mass-less, un-deformed spring with platform. Study the figure below. Just before the block lands on the spring platform, its speed is V_1 . After the block lands on the platform, it compresses the spring a distance h = 0.500 m before momentarily coming to rest. The force constant of the spring is k = 60.00 N/m.

(a) (21) What is the kinetic energy of the block just before landing on the spring platform?
(b) (20) What is speed V_1 of the block just before landing on the spring platform?
(c) (9) What is the work done by the spring during the compression? Is the spring work positive or negative? Circle one. EXPLAIN BRIEFLY.



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3. (48 POINTS) On a frictionless air track, a 0.5000 kg-glider moving to the right at 2.950 m/s collides with a 4.0000 kg glider *at rest.* The collision is *elastic.* Assume the *right* direction is the *positive* direction of motion .

(a) (17 points) What is the velocity of the 0.5000 kg-glider after the collision? Indicate the direction of motion after the collision, right or left.

(b) (17 points) What is the velocity of the 4.0000 kg-glider after the collision? Indicate the direction of motion after the collision, right or left.

(c) (5 points) Using the velocities of parts (a) and (b), compute the total kinetic energy of the system after the collision. Do not round off during intermediate computations.

(d) (5 points) Using the initial velocities before the collision, compute the total kinetic energy of the system before the collision. Do not round off during intermediate computations.

(e) (4 points) Are the answer to parts (c) and (d) equal? Explain.

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4. (12 points) An airplane propeller speeds up in its rotation with uniform angular acceleration $\alpha = 1256.00$ rad/s^2. It is rotating counter clockwise and at t = 0 has an angular speed of $\omega_i = 6280.00$ rad/s.

(a) (6 points) What is the period (in seconds) of the propeller at the moment t = 0 when the angular speed is $\omega_i = 6280.00$ rad/s?

(b) (2 points) How many seconds does it take the propeller to reach an angular speed of 16,700.00 rad/s?

(c) (2 points) What is the angular speed (in rad/s) at t = 10.00 seconds?

(d) (2 points) Through how many revolutions does the propeller turn in the time interval between 0 and 10.00 seconds?

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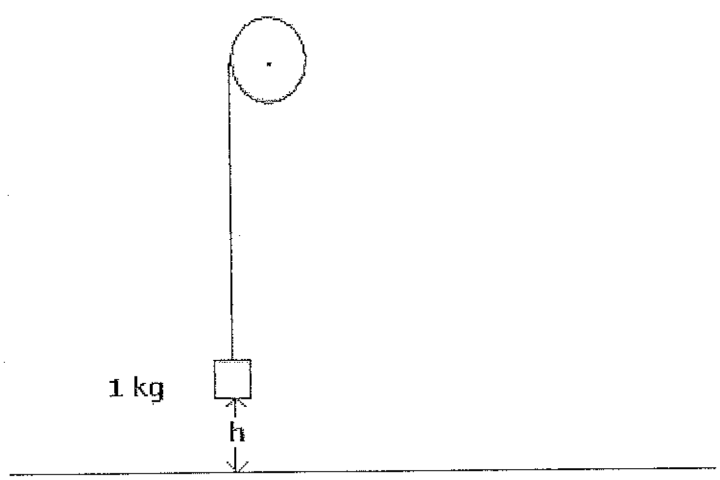
5. EXTRA CREDIT. (22 POINTS) A 1.000-kg block hangs vertically at the end of a string wrapped around a pulley of radius R = 0.250 m and mass M = 2.000-kg, The pulley is shaped in the form of a solid cylinder. Thus, the pulley has $I = \frac{1}{2}MR^2$ about the axis of rotation through the center. The vertically hanging block and pulley are shown at the start of the motion when they are released from *rest.* The block is released from a height h = 1.000 m above the ground.

What is the linear speed v of the block *just before* it hits the ground?



(1)

(a) $\downarrow$

(b) $W_{f_k} < 0$

(c) $W_g < 0$

con $\rightarrow mgh$

(d)

$$\frac{1}{2}mV^2 = mgH + \text{Heat}$$

$$\frac{1}{2}(0.145)(16)^2 = (0.145)(9.8)H + 4.00$$

$$\rightarrow H = \frac{18.56 - 4}{(0.145)(9.8)}$$

$$= 10.25 \text{ (m)}$$

(e)

$$4.00 = f_k \cdot (10.25)$$

$$f_k = \frac{4}{10.25} = 0.39$$

(N)

(2)

(a) $m = 1\text{kg}, \; k = 60 \frac{N}{m}$

$$\frac{1}{2}mv^2 + mgh = \frac{1}{2}kh^2$$

$$\frac{1}{2}mv^2 = \frac{1}{2}kh^2 - mgh$$

$$KE = \frac{1}{2}(60)(0.5)^2 - (1)(9.8)(0.5)$$

$$KE = 7.5 - 4.9$$

$$KE = 2.6 \text{ J}$$

(b) $\frac{1}{2}(1)v^2 = 2.5$

$$v^2 = \sqrt{5} = 2.3 \frac{m}{s}$$

(c) $W_s = -\frac{1}{2}(60)(0.5)^2$

$$= -7.5 \text{ J}$$

(3)

$(0.500)(2.950)$

$= (0.500)V_{1f} + 4 \cdot V_{2f}$

and $0.500 \frac{m}{s} = V_{2f} - V_{1f}$

THUS

(I) $1.475 = 0.5V_{1f} + 4V_{2f}$

(II) $V_{2f} - V_{1f} = 2.950$

$\Rightarrow V_{2f} = 2.95 + V_{1f}$

SUB. INTO I

$1.475 = 0.5V_{1f}$

$+ 4(2.95 + V_{1f})$

$1.475 = 11.8 + 4V_{1f}$

$-10.325 = 4V_{1f}$

$-2.581 \frac{m}{s} = V_{1f}$

$V_{2f} = 2.95 + V_{1f}$

$V_{2f} = 2.95 - 2.581$

$V_{2f} = 0.37 \frac{m}{s}$

(4)

(a) $\omega = 6280 \frac{RAD}{S}$

$T = \frac{2\pi \text{ RAD}}{6280 \frac{RAD}{S}}$

$= 0.00105$ sec

(b) 16700

$= 6280 + 1256t$

$10420 = 1256t$

$8.2962 = t$
seconds

(c) $\omega = 6280 + (1256)(10)$

$= 18842 \frac{RAD}{S}$

(4)

$$\Delta\theta = \left(\frac{\omega_1 + \omega_2}{2}\right)10$$

$$\Delta\theta = \left(\frac{6280 + 18842}{2}\right)(10)$$

$$\Delta\theta = 125610$$

$$\rightarrow \frac{125610}{2\pi} = 2 \times 10^4 \text{ rev}$$

(5)

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{R^2}$$

$$v^2 = \frac{2mgh}{m + \frac{I}{R^2}}$$

$$v^2 = \frac{2mgh}{m + \frac{M}{2}}$$

$$v^2 = \frac{(2)(1)(9.8)(1)}{1 + 1}$$

$$v^2 = \frac{19.6}{2} = 9.8$$

$$v = 3.13 \frac{m}{s}$$