

X2.17a

2050

PHYS-205(17) (Kaldon-20619)

Name _____ SOLUTION _____

WMU-Summer I 2006

Exam 2A - 100,000 points + 20,000 ☆ points Book Title _____

06/04/2006•Rev.4

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers

Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations

Feel Free to Ask Any Questions

☆2a ☆2b ☆2c ☆2e

EXAM 2 [FORM - A]

PHYS-2050 (KALDON-17)

SUMMER I 2006

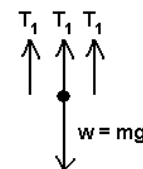
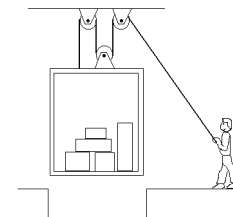
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If $F=ma$,
then does $F^2=mama$?

Problem One – “The One That Goes Up and Down” (35,000 points)

1.) (a) A cargo elevator at an open mine shaft is being pulled on by means of a rope. Draw the Free Body Diagram of the loaded elevator car at rest.

Assume all the cable tensions are the same.



(b) The weight of the loaded elevator at rest is 10,500 N. With what force must the guy pull on the rope?

$$\begin{aligned} \sum F_y &= 3T_1 - w = 0 \\ 3T_1 &= w \\ T_1 &= \frac{w}{3} = \frac{10,500N}{3} = 3500. N \end{aligned}$$

(c) If the elevator is to be lowered at 1.11 m/s², with what force must the guy pull on the rope?

$$\begin{aligned} w &= mg \\ m &= \frac{w}{g} = \frac{10,500N}{9.81m/s^2} = 1070. kg \\ \sum F_y &= 3T_1 - w = ma_y \\ 3T_1 &= w + ma_y \\ T_1 &= \frac{w + ma_y}{3} = \frac{10,500N + (1070. kg)(-1.11m/s^2)}{3} = 3104N \end{aligned}$$

(d) If the elevator is to be lowered at 1.11 m/s, with what force must the guy pull on the rope?

$$\begin{aligned} \sum F_y &= 3T_1 - w = 0 \\ 3T_1 &= w \\ T_1 &= \frac{w}{3} = \frac{10,500N}{3} = 3500. N \end{aligned}$$

Same answer as (b)!

(e) If there was *no* air resistance, then the elevator would be in free fall the whole way. Use conservation of energy to find the speed of the elevator after it has fallen 933 meters.

NOTE: Missing part of the sentence here! If the cable breaks and there was *no* air resistance...

$$\begin{aligned}
 mgh_1 + \frac{1}{2}mv_1^2 &= mgh_2 + \frac{1}{2}mv_2^2 \\
 mgh_1 &= \frac{1}{2}mv_2^2 \\
 gh_1 &= \frac{1}{2}v_2^2 \\
 v_2^2 &= 2gh_1 \\
 v_2 &= \sqrt{2gh_1} \\
 &= \sqrt{2(9.81\text{m/s}^2)(933\text{m})} \\
 &= 135.3\text{m/s}
 \end{aligned}$$

NOTE: OK if student starts with $v_1 = -1.11$ m/s from part (d) rather than from rest...

$$\begin{aligned}
 mgh_1 + \frac{1}{2}mv_1^2 &= mgh_2 + \frac{1}{2}mv_2^2 \quad ; \quad h_2 = 0 \\
 mgh_1 + \frac{1}{2}mv_1^2 &= \frac{1}{2}mv_2^2 \\
 gh_1 + \frac{1}{2}v_1^2 &= \frac{1}{2}v_2^2 \\
 v_2^2 &= 2gh_1 + v_1^2 \\
 v_2 &= \sqrt{2gh_1 + v_1^2} \\
 &= \sqrt{2(9.81\text{m/s}^2)(933\text{m}) + (-1.11\text{m/s})^2} \\
 &= 135.3\text{m/s}
 \end{aligned}$$

Problem Two – “The One With The Star Problems” (30,000 points)

2.) ☆(a) A small red ball (mass $m = 0.200$ kg) is moving to the right with a speed 10.0 m/s at time zero. It is attached to an elastic cord which applies a force to the left with $\vec{F}_{\text{elastic}} = -Cx\hat{i}$. Find the distance d it takes the ball to come to a stop, where $x_0 = 0$ and the coefficient of the cord is $C = 5.00$ N/m, using work and energy.

$$\begin{aligned}
 K &= \frac{1}{2}mv^2 = \frac{1}{2}(0.200\text{kg})(10.0\text{m/s})^2 = 10.00\text{J} \\
 W &= \int \vec{F} \cdot d\vec{s} \\
 &= \int_0^d F_x dx = \int_0^d (-Cx) dx = -C \int_0^d x dx \\
 &= -C \frac{x^2}{2} \Big|_0^d = -\frac{Cd^2}{2} \\
 W &= \Delta K = K_f - K_i = -10.00\text{J} = -\frac{Cd^2}{2} \\
 10.00\text{J} &= \frac{Cd^2}{2} \\
 d^2 &= \frac{2(10.00\text{J})}{C} = \frac{20.00\text{J}}{5.00\text{N/m}} \\
 d &= \sqrt{\frac{20.00\text{J}}{5.00\text{N/m}}} = 2.000\text{m}
 \end{aligned}$$

An object of mass $m = 12.0$ kg begins its motion with the following equation. All other constants are zero.

☆(b) Find the force, F , acting on this object at time $t = 1.00$ sec.

$$\begin{aligned}
 a &= \frac{d^2 x}{dt^2} = (12.0\text{m/s}^6)t^4 \\
 F &= ma = (12.0\text{kg})(12.0\text{m/s}^6)t^4 \\
 &= (144.0\text{kg} \cdot \text{m/s}^6)t^4 \\
 F(t = 1.00\text{sec}) &= (144.0\text{kg} \cdot \text{m/s}^6)(1.00\text{sec})^4 = 144.0\text{N}
 \end{aligned}$$

$$\frac{d^2 x}{dt^2} = (12.0\text{m/s}^6)t^4$$

☆(c) A block of mass $m = 1.00 \text{ kg}$ starts out at rest at a position $x_0 = 4.00 \text{ meters}$, and moves with a force $F_x(t) = \left(20.0 \frac{\text{N}}{\text{s}^2}\right)t^2$. Find the position x of the block after 5.00 seconds. Assume any other constants are zero.

$$\begin{aligned}
 F_x(t) &= \left(20.0 \frac{\text{N}}{\text{s}^2}\right)t^2 \\
 F_x &= ma_x \\
 a_x &= \frac{F_x}{m} = \frac{\left(20.0 \frac{\text{N}}{\text{s}^2}\right)t^2}{1.00\text{kg}} = (20.00\text{m/s}^4)t^2 = \frac{d^2x}{dt^2} \\
 v_x &= \frac{dx}{dt} = \int \frac{d^2x}{dt^2} dt = \int (20.00\text{m/s}^4)t^2 dt \\
 &= \frac{1}{3}(20.00\text{m/s}^4)t^3 + C \quad (C = 0) \\
 x &= \int \frac{dx}{dt} dt = \int \frac{1}{3}(20.00\text{m/s}^4)t^3 dt \\
 &= \frac{1}{3.4}(20.00\text{m/s}^4)t^4 + C \quad (C = x_0 = 4.00\text{m}) \\
 &= (1.667\text{m/s}^4)t^4 + 4.00\text{m} \\
 x(t = 5.00\text{sec}) &= (1.667\text{m/s}^4)(5.00\text{sec})^4 + 4.00\text{m} \\
 &= 1046\text{m}
 \end{aligned}$$

(d) Jerry is putting grocery carts away at Meijer. He takes one of the carts ($m = 10.2 \text{ kg}$) and gives it a shove so it is traveling at 4.75 m/s. It crashes into and sticks with a group of five grocery carts that were just sitting there. Find the speed V of the new group of grocery carts.



$$\begin{aligned}
 P_{\text{before}} &= P_{\text{after}} \\
 m_1v_1 + m_2v_2 + m_3v_3 + m_4v_4 + m_5v_5 + m_6v_6 &= (m_1 + m_2 + m_2 + m_3 + m_4 + m_5 + m_6)V \\
 mv + 0 &= 6mV \\
 V &= \frac{mv}{6m} = \frac{v}{6} = \frac{4.75\text{m/s}}{6} = 0.7917\text{m/s}
 \end{aligned}$$

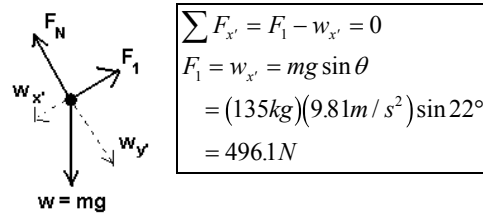
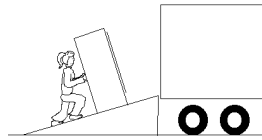
☆(e) An object of mass 1.00 kg has a motion that follows the following equations. Find the magnitude K of the kinetic energy of the object at time $t = 0$ and $t = 10.0 \text{ seconds}$. Then find how much Work was done to move the object – It Won't Take Calculus for this last bit.

$$x(t) = 7.00\text{m} + 6.00\text{m/s}^2 t^2 - 5.00\text{m/s}^3 t^3$$

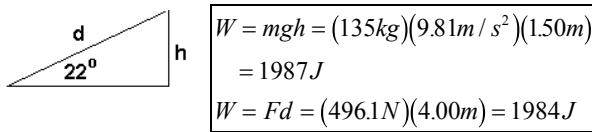
$$\begin{aligned}
 x(t) &= 7.00\text{m} + 6.00\text{m/s}^2 t^2 - 5.00\text{m/s}^3 t^3 \\
 v &= \frac{dx}{dt} = \frac{d}{dt}(7.00\text{m} + 6.00\text{m/s}^2 t^2 - 5.00\text{m/s}^3 t^3) \\
 &= 0 + 2(6.00\text{m/s}^2)t - 3(5.00\text{m/s}^3)t^2 \\
 &= (12.00\text{m/s}^2)t - (15.00\text{m/s}^3)t^2 \\
 v(0) &= 0 \\
 v(t = 10.0\text{sec}) &= (12.00\text{m/s}^2)(10.0\text{sec}) - (15.00\text{m/s}^3)(10.0\text{sec})^2 \\
 &= -1380.\text{m/s} \\
 K_i &= 0 \\
 K_f &= \frac{1}{2}mv^2 = \frac{1}{2}(1.00\text{kg})(-1380.\text{m/s})^2 = 952,200\text{J} \\
 W &= \Delta K = K_f - K_i = 952,200\text{J} - 0 = 952,200\text{J}
 \end{aligned}$$

Problem Three – “The One With All The Angles” (35,000 points)

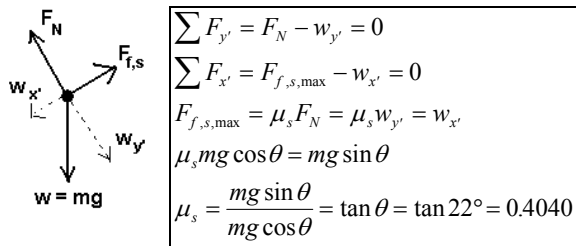
3.) Frida has to get a refrigerator ($m = 135 \text{ kg}$) loaded onto a truck, using a ramp that is angled at 22° . If the refrigerator glides on frictionless rollers, find (a) the force needed to push the refrigerator up the ramp at a constant speed.



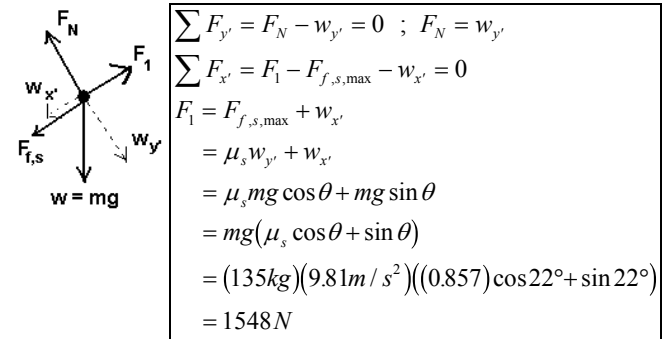
(b) The ramp is 1.50 m tall, while the angled part is 4.00 m long. Show that the work to raise the refrigerator 1.50 m is the same as the work in pushing the refrigerator up the slope without friction.



(c) If the elevator did *not* have the rollers, that it could sit on the ramp and be held in place by static friction without being held by Frida. Find the *minimum* coefficient of static friction, μ_s .



(d) The actual coefficients of friction between the refrigerator and the ramp are 0.857 and 0.657. What is the maximum force Frida can push the stopped refrigerator without having it move up the ramp?



(e) What is the force that Frida needs to apply to the refrigerator to get it up the ramp if it is sliding at a constant speed with friction?

