Physics 115.3 Tutorial #1 – September 20 to October 1, 2010

Rm 130 Physics

A nurse recorded the values shown in the temperature chart for a patient's temperature. Plot a graph of temperature versus elapsed time and from the graph find (a) an estimate of the temperature at noon and (b) the slope of the graph. (c) Would you expect the graph to follow the same trend over the next 12 hours? Explain.

Time	Temp (°F)
10:00 A.M.	100.00
10:30 A.M.	100.45
11:00 A.M.	100.90
11:30 A.M.	101.35
12:45 P.M.	102.48

An object moving at constant speed v around a circle of radius r has an acceleration a directed toward the center of the circle. The SI unit of acceleration is m/s^2. (a) Use dimensional analysis to find a as a function of v and r. (b) If the speed is increased 10.0%, by what percentage does the radial acceleration increase?

A toy freight train consists of an engine and three identical cars. The train is moving to the right at constant speed along a straight, level track. Three spring scales are used to connect the cars as follows: spring scale A is located between the engine and the first car; scale B is between the first and second cars; scale C is between the second and third cars. (a) If air resistance and friction are negligible, what are the readings on the three spring scales A, B, and C? (b) If air resistance and friction together cause a force of magnitude 5.5 N on each car, directed toward the left, find the readings of scales A, B, and C.

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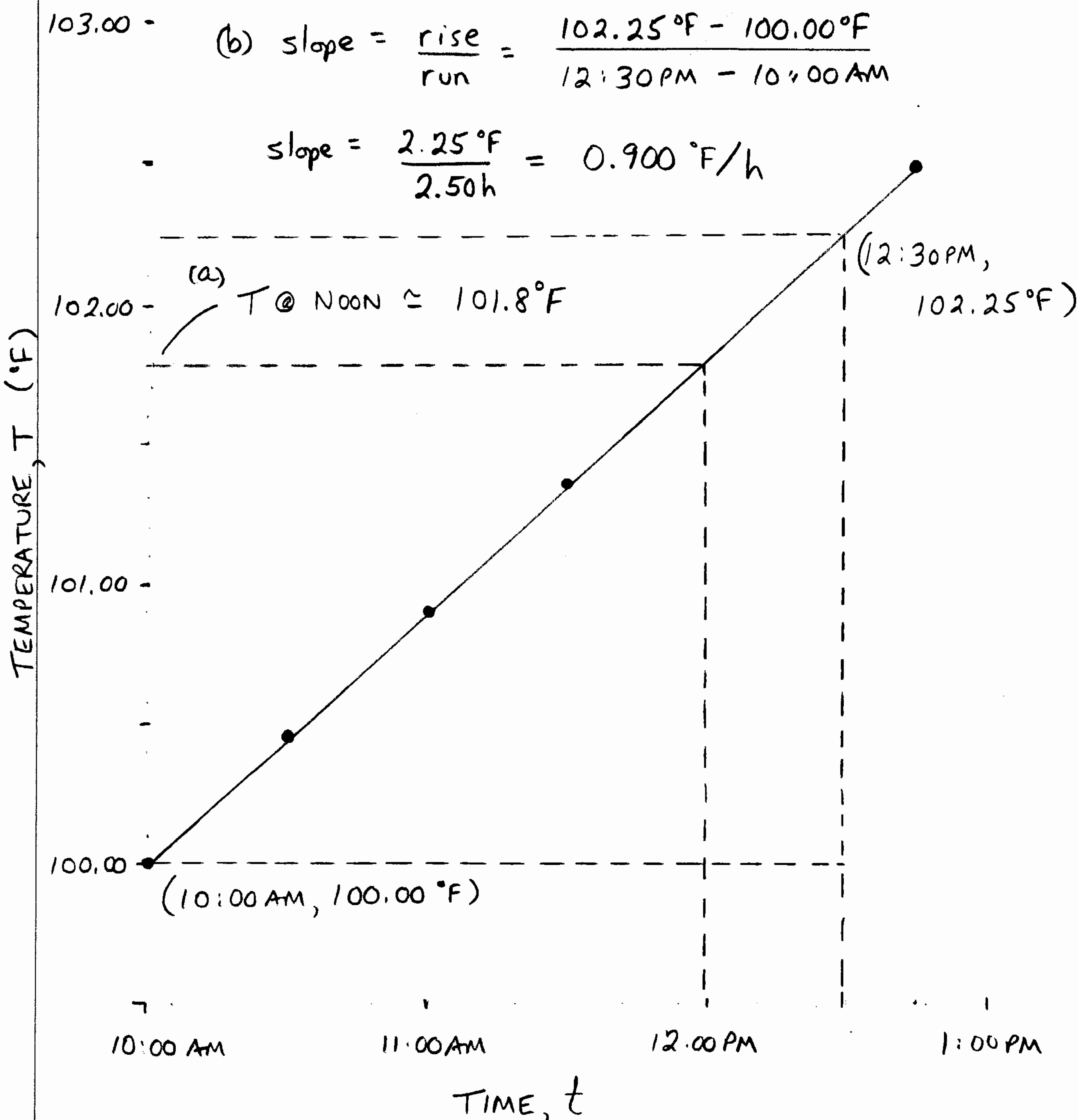
PHYS 115 - TUTORIAL 1 - # 1.39

(b) $\text{slope} = \dfrac{\text{rise}}{\text{run}} = \dfrac{102.25\,^\circ F - 100.00\,^\circ F}{12{:}30\text{PM} - 10{:}00\text{AM}}$

$\text{slope} = \dfrac{2.25\,^\circ F}{2.50\,h} = 0.900\,^\circ F/h$



(c) If the graph follows the same trend over the next 12 hours, the patient's temperature would be

$102.48\,^\circ F + 12h\left(0.900\,^\circ F/h\right) = 113.3\,^\circ F$

∴ not possible, patient would die before reaching this temp.

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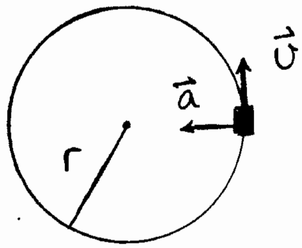
PHYS 115 - TUTORIAL 1 - # 1.61



v : speed $\quad [v] = [L]/[T]$

r : radius $\quad [r] = [L]$

a : acceleration $\quad [a] = [L]/[T]^2$

(a) Assuming that "a" depends only on v and r, and applying dimensional analysis

$$a = c v^x r^y$$

where x and y are exponents to be determined and c is a dimensionless constant (which may be 0)

$$\therefore \frac{[L]}{[T]^2} = \left(\frac{[L]}{[T]}\right)^x [L]^y$$

$$\frac{[L]}{[T]^2} = \frac{[L]^x}{[T]^x} \cdot [L]^y$$

$$\frac{[L]}{[T]^2} = \frac{[L]^{x+y}}{[T]^x}$$

Considering the dimension of time, x must be 2.

Considering the dimension of length, $x+y$ must be 1.

$$x+y = 1 \Rightarrow y = 1-x \Rightarrow y = 1-2 \Rightarrow y = -1.$$

$$\therefore a = c v^2 r^{-1} \; ; \quad a = c\frac{v^2}{r}$$

(b) v increases by 10% $\Rightarrow v_2 = v_1(1 + 10/100) = v_1(1.10)$

$$\therefore a_2 = \frac{c v_2^2}{r_2} = \frac{c(v_1(1.100))^2}{r_2} = \frac{c\, v_1^2 (1.210)}{r_2} = \frac{(1.210) c v_1^2}{r_1}$$

b/c r hasn't changed.

$$\therefore a_2 = 1.210 a_1 = a_1\left(1 + \frac{21.0}{100}\right)$$

a has increased by 21.0%.

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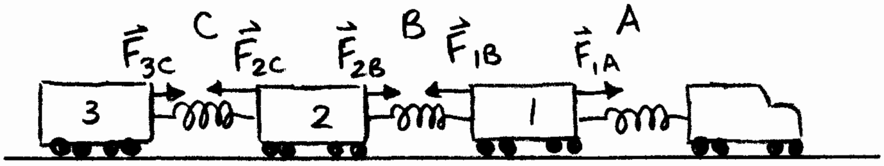
PHYS 115 - TUTORIAL 1 - # 2.89



moving to right at constant speed along straight, level track.

$\therefore$ constant $\vec{v}$

$\therefore$ $\Sigma\vec{F}=0$ for each car (Newton I)

(a) Notation:

$\vec{F}_{1A}$ is force on car 1 due to spring scale A.

Note that $\Sigma\vec{F}=0$ for each car.

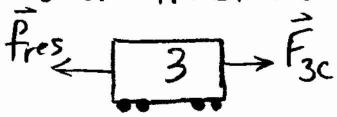
$\therefore$ For car 3, $\vec{F}_{3C}=0$.

For car 2, $\vec{F}_{2B}+\vec{F}_{2C}=0$, but $F_{2C}=F_{3C}=0$, so $\vec{F}_{2B}=0$

For car 1, $\vec{F}_{1A}+\vec{F}_{1B}=0$, but $F_{1B}=F_{2B}=0$, so $\vec{F}_{1A}=0$

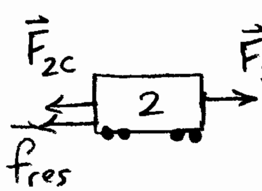
$\therefore$ All 3 spring scales read 0.

(b), Let $\vec{f}_{res}$ be the combined force of air resistance
(c) and friction acting on each car, directed to left (opposite the motion)



$\Sigma\vec{F}_3=0 \Rightarrow \vec{F}_{3C}+\vec{f}_{res}=0.$

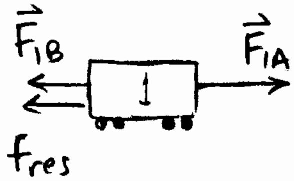
$\therefore$ $F_{3C}=f_{res}=\underline{\underline{5.5N}}$ scale C reading



$\Sigma\vec{F}_2=0 \Rightarrow \vec{F}_{2B}+\vec{F}_{2C}+\vec{f}_{res}=0$

$\therefore$ $F_{2B}=F_{2C}+f_{res}$ (magnitudes)

Since $F_{2C}=F_{3C}=f_{res}$, $F_{2B}=f_{res}+f_{res}=2f_{res}$ 11.0 N (scale B reading)



$\Sigma\vec{F}_1=0 \Rightarrow \vec{F}_{1A}+\vec{F}_{1B}+\vec{f}_{res}=0$

$\therefore$ $F_{1A}=F_{1B}+f_{res}$ (magnitudes)

Since $F_{1B}=F_{2B}=2f_{res}$, $F_{1A}=2f_{res}+f_{res}=3f_{res}$ 16.5 N (scale A)

Physics 115.3 Tutorial #2 – October 4 to 18, 2010

Rm 130 Physics

You want to push a 65-kg box up a 25° ramp by pushing with a force parallel to the ramp. The coefficient of kinetic friction between the ramp and the box is 0.30. With what magnitude force should you push on the box so that it moves up the ramp in a straight line at constant speed?

A crate of oranges weighing 180 N rests on a flatbed truck 2.0 m from the back of the truck. The coefficients of friction between the crate and the bed are $\mu_s = 0.30$ and $\mu_k = 0.20$. The truck drives on a straight, level highway at a constant 8.0 m/s. (a) What is the force of friction acting on the crate? (b) If the truck speeds up with an acceleration of 1.0 m/s^2, what is the force of friction on the crate? (c) What is the maximum acceleration the truck can have without the crate starting to slide?

A rocket is launched from rest. After 8.0 min, it is 160 km above the Earth's surface and is moving at a speed of 7600 m/s. Assuming the rocket moves up in a straight line, calculate its average velocity (in m/s) and average acceleration (in m/s^2)?

Is it possible that the rocket moves with constant acceleration? Hint: Use the initial and final velocities and elapsed time given above to calculate the displacement that would occur if the acceleration was constant.

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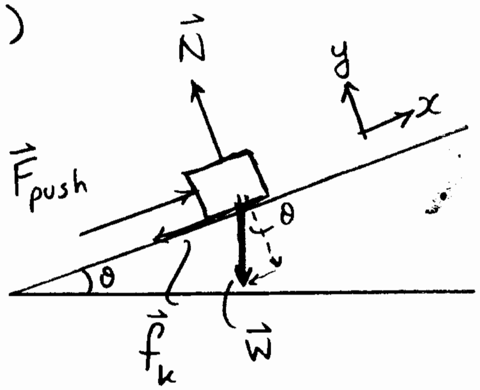
PHYS 115 TUTORIAL 2

1. (2.83)



Since 3 of 4 forces are // or ⊥ to ramp, choose coordinate system as shown.

Moving up the ramp at constant speed ⇒ $\Sigma\vec{F} = 0$.

$\therefore \; \Sigma F_x = 0$ and $\Sigma F_y = 0$

$F_{push_x} + f_{k_x} + W_x = 0$

$N_y + W_y = 0$

$+N - W\cos\theta = 0$

$+F_{push} - f_k - mg\sin\theta = 0$

$N = W\cos\theta$

$F_{push} = mg\sin\theta + f_k$

$N = mg\cos\theta$

$F_{push} = mg\sin\theta + \mu_k N$

$F_{push} = mg\sin\theta + \mu_k mg\cos\theta$

$F_{push} = mg(\sin\theta + \mu_k\cos\theta)$

$F_{push} = (65\,kg)(9.80\,m/s^2)[\sin 25° + 0.30\cos 25°]$

$F_{push} = 4.4 \times 10^2\,N$

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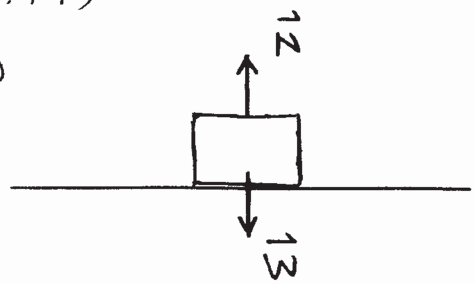
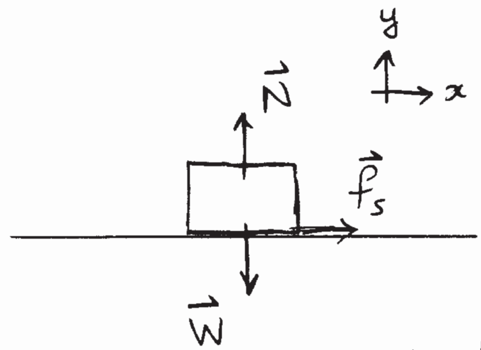
2. (3.79)

(a)



At constant velocity, $\Sigma \vec{F} = 0$ so there is no frictional force acting on the crate (b/c there is no other horizontal force on the crate).

(b)



The truck now has an acceleration of $1.0\ m/s^2$ to the right. If the crate is to remain at rest relative to the truck, it must also have an acceleration of $1.0\ m/s^2$ to the right. This acceleration will be caused by static friction b/w the crate and the truck, assuming the required $\vec{f}_s$ is $< \vec{f}_{s,max}$. $f_{s,max} = \mu_s N$ and from the FBD, $N = mg$.

$\therefore f_{s,max} = \mu_s mg$. From Newton II, $\Sigma \vec{F} = m\vec{a}$

$$f_{s,max} = (0.30)(180N)$$
$$f_{s,max} = 54\ N$$

$$f_s = \frac{180N}{g} \cdot 1.0\ m/s^2$$
$$f_s = 18\ N$$

Since $f_s < f_{s,max}$, the force of friction b/w the crate and the truck is 18N.

(c) The max. possible acceleration before sliding occurs is when f_s is maximum. Since $f_{s,max} = 54N$,

$$a_{max} = \frac{f_{s,max}}{m} = \frac{54N}{180N/g} = \frac{54}{180} g = 0.30g = 2.9\ m/s^2$$

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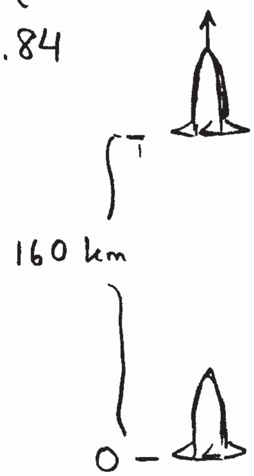
3. (3.84 and 3.85)

3.84



$v_f = +7.6\ \text{km/s}$, $t_f = 8.0$ min

$\uparrow +x$

$v_i = 0$, $t_i = 0$

(a) $\vec{v}_{av} = \dfrac{\Delta\vec{r}}{\Delta t} = +\dfrac{160\ \text{km}}{8.0\ \text{min}}$

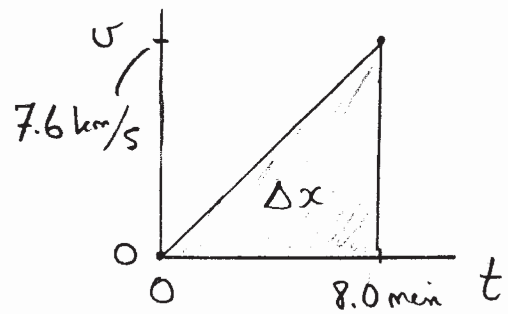
$v_{av} = +20\ \dfrac{\text{km}}{\text{min}} \times \dfrac{1\ \text{min}}{60\ \text{s}} \times \dfrac{1000\ \text{m}}{\text{km}}$

$v_{av} = +333\ \text{m/s}$
$(3.3 \times 10^2\ \text{m/s})$

(b) $\vec{a}_{av} = \dfrac{\Delta\vec{v}}{\Delta t} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t} = \dfrac{+7.6\ \text{km/s} - 0}{8.0\ \text{min}} = +0.95\ \dfrac{\text{km}}{\text{s}\cdot\text{min}}$

$a_{av} = +0.95\ \dfrac{\text{km}}{\text{s}\cdot\text{min}} \times \dfrac{1\ \text{min}}{60\ \text{s}} \times \dfrac{1000\ \text{m}}{\text{km}} = +15.8\ \text{m/s}^2$
$(+16\ \text{m/s}^2)$

3.85 If the acceleration is constant, then the graph of v vs t is linear, with slope of a $(= a_{av})$.



Recall that displacement for linear motion is the area under v vs t graph. (area of a triangle)

$\therefore |\Delta\vec{r}| = \Delta x = \frac{1}{2}bh$

$\Delta x = \frac{1}{2}(8.0\ \text{min})(7.6\ \text{km/s}) = 30.4\ \cancel{\text{min}} \cdot \dfrac{\text{km}}{\cancel{\text{s}}} \times \dfrac{60\ \cancel{\text{s}}}{\cancel{\text{min}}}$

$\Delta x = 1.80 \times 10^3\ \text{km}$

since this is much different from the actual displacement of 0.16×10^3 km, the acceleration is not constant.

Physics 115.3 Tutorial #3 – October 19 to November 1, 2010

Rm 130 Physics

A cannonball is catapulted toward a castle. The cannonball's velocity when it leaves the catapult is 40 m/s at an angle of 37° with respect to the horizontal and the cannonball is 7.0 m above the ground at this time.
(a) What is the maximum height above the ground reached by the cannonball? (b) Assuming the cannonball makes it over the castle walls and lands back on the ground, at what horizontal distance from its release point will it land? (c) What are the x- and y-components of the cannonball's velocity just before it lands? The y-axis points up.

A coin is placed on a turntable that is rotating at 33.3 rpm. If the coefficient of static friction between the coin and the turntable is 0.1, how far from the centre of the turntable can the coin be placed without having it slip off?

Sam pushes a 10.0-kg sack of bread flour on a frictionless horizontal surface with a constant horizontal force of 2.0 N starting from rest. (a) What is the kinetic energy of the sack after Sam has pushed it a distance of 35 cm?
(b) What is the speed of the sack after Sam has pushed it a distance of 35 cm?

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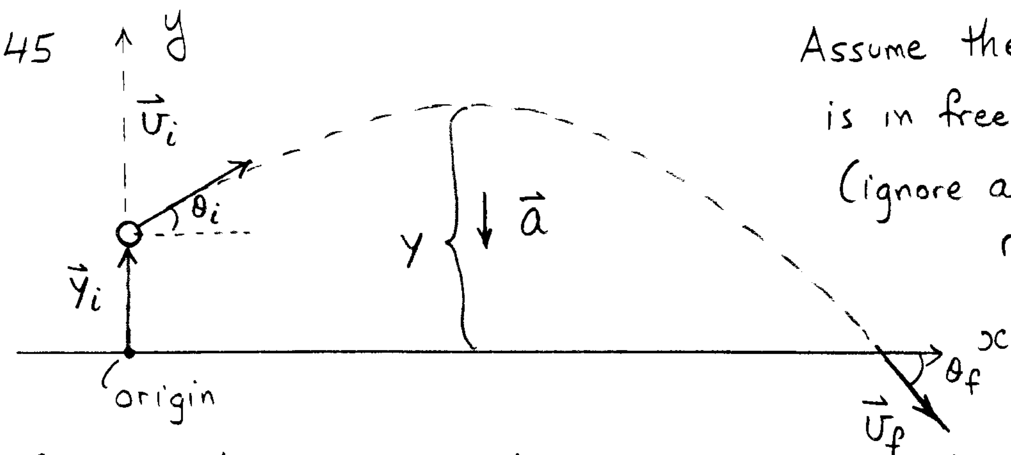
TUTORIAL 3

4.45



Assume the ball is in freefall (ignore air resistance)

Resolve the motion into x and y coordinates with x horizontal and +y vertically up.

$x_i = 0$	$y_i = +7.0\,m$	GIVEN:
$x_f = ?$	$y_f = 0$	$v_i = 40\,m/s$
$v_{ix} = v_i \cos\theta_i$	$v_{iy} = v_i \sin\theta_i$	$\theta_i = 37°$
		$y_i = 7.0\,m$
$a_x = 0$	$a_y = -9.8\,m/s^2$	$a = 9.80\,m/s^2$ DOWN
$v_{fx} = v_{ix}$	$v_{fy} = ?$	

(a) At maximum height, $v_y = 0$.

Use eq'n 4-10: $v_y^2 - v_{iy}^2 = 2a_y \Delta y_{max}$

$$\Delta y_{max} = \frac{\cancel{v_y^2} - v_{iy}^2}{2a_y} = \frac{0 - (v_i \sin\theta_i)^2}{2a_y} = \frac{-(40\,m/s \sin 37°)^2}{2(-9.8\,m/s^2)}$$

$$\Delta y_{max} = 30\,m = y_{max} - y_i$$

$$\therefore\ y_{max} = y_i + \Delta y_{max} = +7.0\,m + 30\,m = +37\,m$$

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(b) In x-dir'n, $\Delta x = v_x \Delta t$

Must determine Δt, use eq'n 4-9 : $\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y(\Delta t)^2$

Note that this eq'n is quadratic in Δt:

$$0 = \frac{1}{2}a_y(\Delta t)^2 + v_{iy}(\Delta t) - \Delta y$$

$$0 = \frac{1}{2}(-9.8\,m/s^2)(\Delta t)^2 + (40\,m/s \sin 37°)(\Delta t) - (-7.0\,m)$$

$$0 = -4.9\,m/s^2(\Delta t)^2 + (24.1\,m/s)\Delta t + 7.0\,m$$

$$\Delta t = \frac{-24.1\,m/s \pm \sqrt{(24.1\,m/s)^2 - 4(-4.9\,m/s^2)(+7.0\,m)}}{2(-4.9\,m/s^2)}$$

$\Delta t = -0.275s$; 5.19s   time must be +ve.

$$\Delta x = v_x \Delta t = (v_i \cos\theta_i)\Delta t = (40\,m/s \cos 37°)(5.19s)$$

$$\boxed{\Delta x = 1.7 \times 10^2\,m}$$

(c) $v_{fx} = v_{ix} = 40\,m/s \cos 37° = \boxed{+32\,m/s}$

From eq'n 4-7, $\Delta v_y = a_y \Delta t$

$$v_{fy} - v_{iy} = a_y \Delta t$$

$$v_{fy} = v_{iy} + a_y\Delta t = v_i \sin\theta_i + a_y \Delta t$$

$$v_{fy} = 40\,m/s \sin 37° + (-9.8\,m/s^2)(5.19s)$$

$$v_{fy} = \boxed{-27\,m/s}$$

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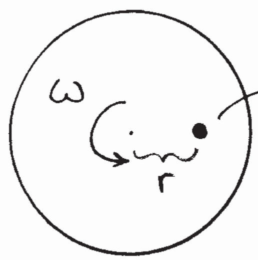
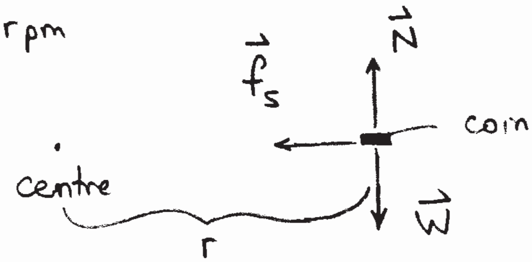
5.79

$\omega = 33.3$ rpm



TOP VIEW



SIDE VIEW

$\mu_s = 0.10$

The radial force keeping the coin moving in a circle is $\vec{f}_s$. The maximum possible value of r occurs when $\vec{f}_s = \vec{f}_{s,max}$. Choose the coordinate axes to be radial and vertical (y).

$$\Sigma F_r = ma_r \qquad\qquad \Sigma F_y = 0$$

$$f_{s,max} = m r_{max} |\omega|^2 \qquad\qquad +N - W = 0$$

$$N = W$$

$$\mu_s N = m r_{max} |\omega|^2 \qquad\qquad N = mg$$

$$\mu_s (\cancel{m} g) = \cancel{m} r_{max} |\omega|^2$$

$$r_{max} = \frac{\mu_s g}{|\omega|^2}$$

$$r_{max} = \frac{0.1\,(9.80\,m/s^2)}{(33.3\,rev/min)^2} \times \left(\frac{1\,rev}{2\pi\,rad}\right)^2 \times \left(\frac{60\,s}{min}\right)^2 = 0.08\,m$$

$$\boxed{r_{max} = 8\,cm}$$ (only 1 s.f. b/c $\mu_s = 0.1$)

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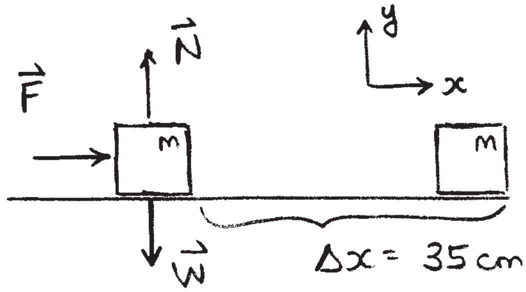
6.13



$F = 2.0\,N$

$m = 10.0\,kg$

$v_i = 0$

$\boxed{\text{METHOD 1}}$: Newton II, $\Sigma \vec{F} = m\vec{a} \Rightarrow \Sigma F_x = ma_x$; $\Sigma F_y = 0$

$\Sigma F_x = ma_x \Rightarrow F = ma_x \Rightarrow a_x = F/m$

From kinematics, $v_{fx}^2 - v_{ix}^2 = 2a_x \Delta x$

$$v_{f_x} = \left[v_{ix}^2 + 2\left(\frac{F}{m}\right)\Delta x\right]^{1/2} = \left(0 + \frac{2(2.0N)}{10.0\,kg}\cdot 0.35m\right)^{1/2}$$

$v_{f_x} = 0.37\,m/s$ (b)

$$KE_f = \frac{1}{2}mv_{f_x}^2 = \frac{1}{2}(10.0\,kg)(0.37\,m/s)^2 = 0.70\,J$$ (a)

$\boxed{\text{METHOD 2}}$: Work-kinetic energy theorem $W_{total} = \Delta K$

$W_{total} = K_f - K_i$

$F \Delta x \cos 0° = K_f$

$(2.0N)(0.35m) = K_f$

$K_f = 0.70\,J$ (a)

$$K_f = \frac{1}{2}mv_f^2 \Rightarrow v_f = \sqrt{\frac{2K_f}{m}}$$

$$v_f = \sqrt{\frac{2(0.70\,J)}{10.0\,kg}} = 0.37\,m/s$$

Physics 115.3 Tutorial #4 – November 2 to 19, 2010

Rm 130 Physics

6.87. When a 0.20-kg mass is suspended from a vertically hanging spring, it stretches the spring from its original length of 5.0 cm to a *total* length of 6.0 cm. Calculate the spring constant. The spring with the same mass attached is then placed on a horizontal frictionless surface. The mass is pulled so that the spring stretches to a *total* length of 10.0 cm; then the mass is released and it oscillates back and forth. What is the maximum speed of the mass as it oscillates?

7.85. A police officer is investigating the scene of an accident where two cars collided at an intersection. One car with a mass of 1100 kg moving west had collided with a 1300-kg car moving north. The two cars, stuck together, skid at an angle of 30° north of west for a distance of 17 m. The coefficient of kinetic friction between the tires and the road is 0.80. The speed limit for each car was 70 km/h. Was either car speeding?

16.11. A total charge of 7.50×10^{-6} C is distributed on two different small metal spheres. When the spheres are 6.00 cm apart, they each feel a repulsive force of 20.0 N. How much charge is on each sphere?

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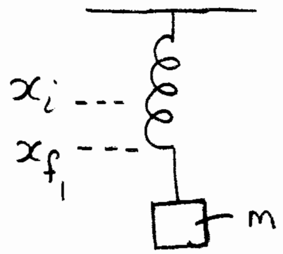
Phys 115 TUTORIAL 4

1. (6.87)

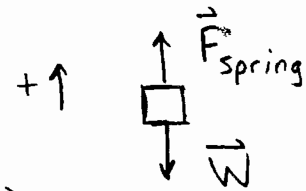


$m = 0.20\ \text{kg}$

$x_i = 5.0\ \text{cm}$

$x_{f_1} = 6.0\ \text{cm}$

FBD for hanging mass:



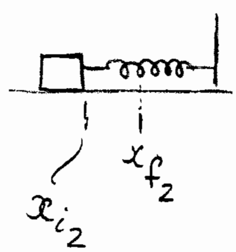
$\Sigma \vec{F} = 0$ (mass is hanging at rest)

$$F_{spring} - W = 0$$

$$k(x_{f_1} - x_i) - mg = 0$$

$$k = \frac{mg}{(x_{f_1} - x_i)}$$

When mass is on horizontal frictionless surface, $W_{nc} = 0$ (no friction, and $\vec{N}$ does no work) $\therefore\ U_{i_2} + K_{i_2} = U_{f_2} + K_{f_2}$



$x_{i_2} = 10.0\ \text{cm}$

$x_{f_2} = 5.0\ \text{cm}$

$K_{i_2} = 0$ b/c mass is released from rest.

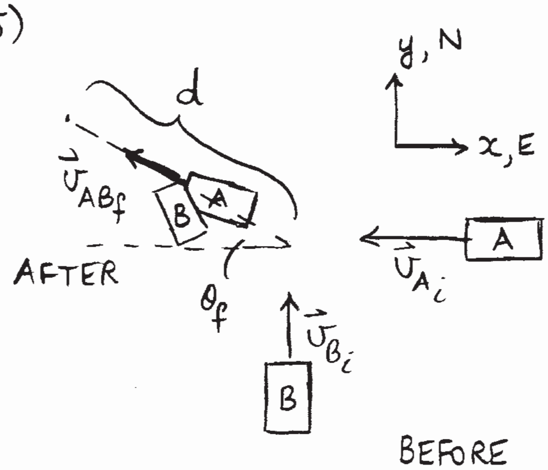
Max. speed will occur when <u>all</u> the initial elastic potential energy is transferred to kinetic energy.

$$\cancel{\tfrac{1}{2}} k(x_{i_2} - x_{f_2})^2 + 0 = 0 + \cancel{\tfrac{1}{2}} m v_{f_2}^2$$

$$\frac{\cancel{m}g}{(x_{f_1} - x_i)}(x_{i_2} - x_{f_2})^2 = m v_f^2 \Rightarrow v_f = \sqrt{\frac{g}{(x_{f_1} - x_i)}}\,(x_{i_2} - x_{f_2})$$

$$v_f = \sqrt{\frac{9.80\ \text{m/s}^2}{(0.060\ \text{m} - 0.050\ \text{m})}}\,(0.100\ \text{m} - 0.050\ \text{m}) = 1.6\ \text{m/s}$$

2. (7.85)



$m_A = 1100$ kg

$m_B = 1300$ kg

$\theta_f = 30°$ N of W

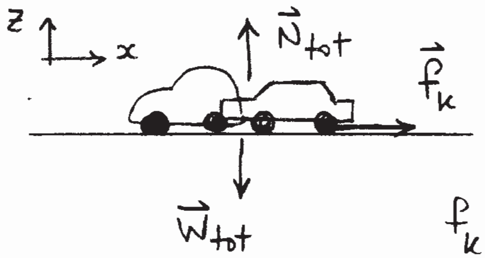
d = skid distance = 17 m

$\mu_k = 0.80$

Asked to determine v_{A_i} and v_{B_i}.

Use post-collision info to determine v_{AB_f} then use cons. of linear momentum to determine v_{A_i} and v_{B_i}.

After the collision, the locked cars are skidding:



$$\Sigma F_z = 0$$

$$N_{tot} - W_{tot} = 0 \Rightarrow N_{tot} = W_{tot}$$

$$f_k = \mu_k N_{tot} = \mu_k W_{tot} = \mu_k (m_A + m_B) g$$

$$U_i + K_i + W_{nc} = U_f + K_f$$

where i: immediately after collision

f: once cars have skidded to a stop. ($K_f = 0$)

Assume level road: $U_i = U_f$

$$K_i + W_{nc} = 0$$

$$\frac{1}{2}(m_A + m_B) v_{AB_f}^2 + f_k \cdot d \cos(180°) = 0$$

$$v_{AB_f} = \sqrt{\frac{2 f_k d}{m_A + m_B}} = \sqrt{\frac{2\mu_k (m_A + m_B) g d}{(m_A + m_B)}} = \sqrt{2\mu_k g d}$$

Now apply cons. of momentum: $\vec{P}_{A_i} + \vec{P}_{B_i} = \vec{P}_{A_f} + \vec{P}_{B_f}$

$$m_A v_{A_{ix}} + m_B v_{B_{ix}} = m_A v_{A_{fx}} + m_B v_{B_{fx}}$$

and

$$m_A v_{A_{iy}} + m_B v_{B_{iy}} = m_A v_{A_{fy}} + m_B v_{B_{fy}}$$

x-dir'n: $-m_A v_{A_i} + 0 = (m_A + m_B)(-v_{AB_f}\cos\theta_f)$

$$v_{A_i} = \frac{(m_A + m_B)}{m_A}\sqrt{2\mu_k g d}\,\cos\theta_f$$

$$v_{A_i} = \frac{(1100\,kg + 1300\,kg)}{1100\,kg}\sqrt{2(0.80)(9.80\,m/s^2)(17\,m)}\;\cos 30°$$

$$v_{A_i} = 30.8\,m/s \times \frac{3600\,s}{h} \times \frac{1\,km}{1000\,m} = 111\,km/h$$ SPEEDING

y-dir'n: $0 + m_B v_{B_i} = (m_A + m_B)\,v_{AB_f}\sin\theta_f$

$$v_{B_i} = \frac{(m_A + m_B)}{m_B}\sqrt{2\mu_k g d}\;\sin\theta_f$$

$$v_{B_i} = \frac{(1100\,kg + 1300\,kg)}{1300\,kg}\sqrt{2(0.80)(9.8\,m/s^2)(17\,m)}\;\sin 30°$$

$$v_{B_i} = 15.1\,m/s \times \frac{3600\,s}{h} \times \frac{1\,km}{1000\,m} = 54\,km/h$$

WITHIN LIMIT

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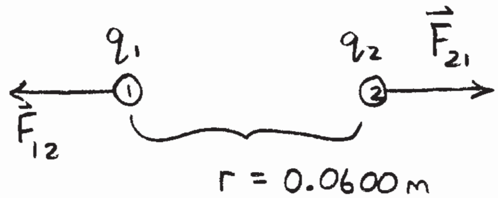
3. (16.11)



$$F_{12} = F_{21} = 20.0\,N$$

$$q_1 + q_2 = 7.50\times10^{-6}C = q_{tot}$$

$$F_{12} = \frac{k|q_1||q_2|}{r^2} = \frac{k|q_1||q_{tot}-q_1|}{r^2}$$

Since the force is repulsive and q_1+q_2 is +ve, we know that both q_1 and q_2 must be +ve.

$$F_{12} = \frac{k(q_1)(q_{tot}-q_1)}{r^2} \Rightarrow F_{12}\cdot r^2 = kq_1q_{tot} - kq_1^2$$

$$kq_1^2 - kq_1q_{tot} + F_{12}r^2 = 0 \qquad \text{QUADRATIC}$$

$$q_1 = \frac{kq_{tot} \pm \sqrt{(-kq_{tot})^2 - 4(k)(F_{12}r^2)}}{2k}$$

$$q_1 = 6.22\times10^{-6}C \;;\; 1.29\times10^{-6}C$$

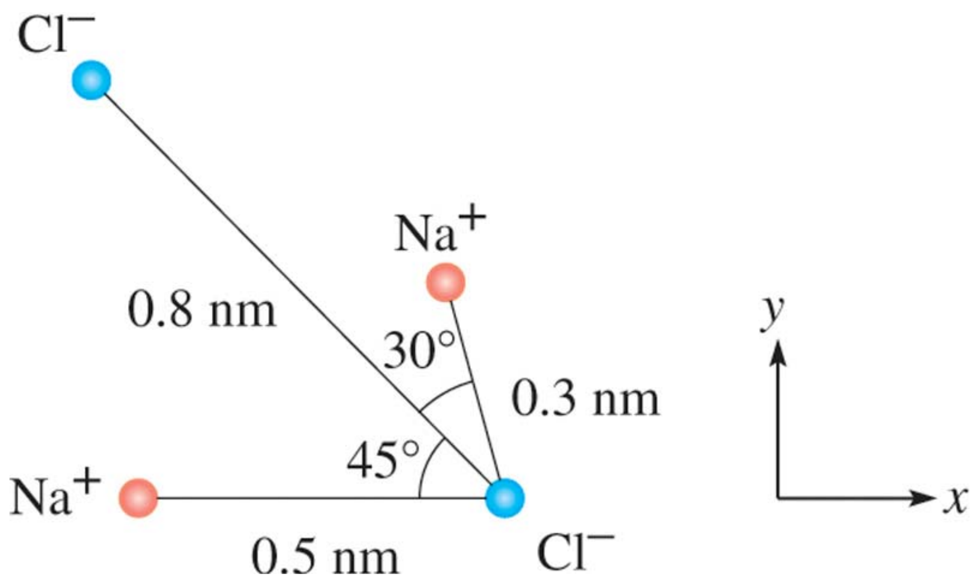
$$q_2 = q_{tot} - q_1 = 7.50\times10^{-6}C - 6.22\times10^{-6}C = 1.28\times10^{-6}C$$

The two charges are $6.22\times10^{-6}C$ and $1.29\times10^{-6}C$

Physics 115.3 Tutorial #5 – November 22 to December 3, 2010

Rm 130 Physics

What is the electric force on the chloride ion in the lower right-hand corner in the diagram? Since the ions are in water, the "effective charge" on the chloride ions is -2×10^{-21} C and that of the sodium ions is $+2 \times 10^{-21}$ C. The effective charge is a way to account for the partial shielding due to nearby water molecules. Assume that all four ions are coplanar.



Consider a 60.0-W lightbulb and a 100.0-W lightbulb designed for use in a household lamp socket at 120 V. (a) What are the resistances of these two bulbs? (b) If they are wired together in a series circuit, which bulb shines brighter (dissipates more power)? Explain. (c) If they are connected in parallel in a circuit, which bulb shines brighter? Explain.

An electron moves with a speed of 2.0×10^5 m/s in a uniform magnetic field of 1.4 T that points south. At one instant, the electron experiences an upward magnetic force of 1.6×10^{-14} N. In what direction is the electron moving at that instant? Be specific: give the angle(s) with respect to N, S, E, W, up, down. (If there is more than one possible answer, find all the possibilities.)

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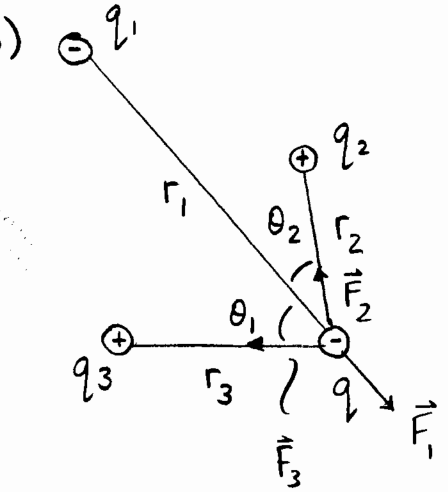
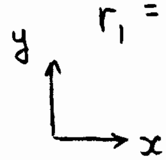
TUTORIAL #5

1. (16.80)



$q, q_1 = -2\times10^{-21}C$

$q_2, q_3 = +2\times10^{-21}C$



$r_1 = 0.8\text{ nm}$, $r_2 = 0.3\text{ nm}$,

$r_3 = 0.5\text{ nm}$

$\theta_1 = 45°$

$\theta_2 = 30°$

Use Coulomb's Law to determine the magnitudes of the electric forces on q due to q_1, q_2, and q_3.

$$F_1 = \frac{k|qq_1|}{r_1^2} = \frac{8.99\times10^9\,\text{N}\cdot\text{m}^2/\text{C}^2\,|(-2\times10^{-21}C)(-2\times10^{-21}C)|}{(0.8\text{ nm})^2}$$

$$F_1 = 5.6\times10^{-14}\text{ N}$$

Similarly, $F_2 = 4.0\times10^{-13}\text{N}$ and $F_3 = 1.4\times10^{-13}\text{N}$

Now add $\vec{F}_1, \vec{F}_2, \vec{F}_3$ (vectors, so add by components)

x	y
$F_{1x} = +F_1\cos\theta_1$	$F_{1y} = -F_1\sin\theta_1$
$F_{2x} = -F_2\cos(\theta_1+\theta_2)$	$F_{2y} = +F_2\sin(\theta_1+\theta_2)$
$F_{3x} = -F_3$	$F_{3y} = 0$

$$F_{tot_x} = 3.96\times10^{-14}\text{N} - 1.03\times10^{-13}\text{N} - 1.4\times10^{-13}\text{N}$$

$$F_{tot_x} = -2.0\times10^{-13}\text{N}$$

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$$F_{tot_y} = -3.96\times10^{-14}\,N + 3.86\times10^{-13}\,N = 3.5\times10^{-13}\,N$$

$$F_{tot} = \left(F_{tot_x}^{2} + F_{tot_y}^{2}\right)^{1/2} = 4\times10^{-13}\,N$$

@

$$\theta_{tot} = \text{invtan}\left(\frac{F_{tot_y}}{F_{tot_x}}\right) = 60^\circ \text{ above } -\hat{x} \text{ axis}$$

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2

(a) The power rating assumes that the bulb is the only element in the circuit.

$\therefore$ R can be determined from $P = \frac{V^2}{R}$.

$$R_{60} = \frac{V^2}{P} = \frac{(120V)^2}{60.0W} = 240\,\Omega$$

$$R_{100} = \frac{(120V)^2}{100W} = 144\,\Omega$$

(b) When the bulbs are in series, they have the same current.

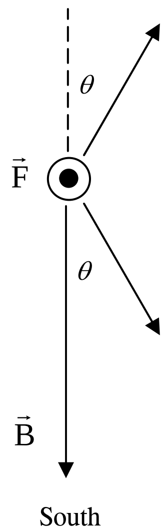
Since $P = I^2R$, the 60W bulb will dissipate more power and $\therefore$ shine brighter.

(c) In a parallel connection, the voltage drop is the same, so from $P = \frac{V^2}{R}$ the 100W bulb dissipates more power and $\therefore$ shines brighter.

Question 3 Solution

> An electron moves with a speed of 2.0×10^5 m/s in a uniform magnetic field of 1.4 T that points south. At one instant, the electron experiences an upward magnetic force of 1.6×10^{-14} N. In what direction is the electron moving at that instant? Be specific: give the angle(s) with respect to N, S, E, W, up, down. (If there is more than one possible answer, find all the possibilities.)

Given that the magnetic force is upward (vertical) and that the magnetic force is perpendicular to the velocity, the velocity of the electron must be in the horizontal plane at that instant.



From the right-hand-rule (RHR), to obtain an upward force when the magnetic field is directed south, $q\vec{v}$ must be directed on the westward side of north-south. Since q is negative for an electron, this means that $\vec{v}$ must be directed on the eastward side of north-south.

The possible values of θ can now be calculated from the expression for magnetic force.

$$F = |q|\upsilon B \sin\theta$$

$$\sin\theta = \frac{F}{|q|\upsilon B}$$

$$\theta = \sin^{-1}\left(\frac{F}{|q|\upsilon B}\right) = \sin^{-1}\left(\frac{1.6\times 10^{-14}\ \mathrm{N}}{\left|-1.6\times 10^{-19}\ \mathrm{C}\right|(2.0\times 10^{5}\ \mathrm{m/s})(1.4\ \mathrm{T})}\right) = 21^\circ, 180^\circ - 21^\circ$$

So, at the instant described in the question, the electron is moving in a direction of 21° East of North, or a direction of 21° East of South.