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20653408

Physics 135A Midterm

Contains 9 pages of work and two PhET extension images

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10/11/24
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Algebra Based Physics I - Midterm #1

Unit 0: (1-9)

① Which of the following represents the density of lead?
I used limits to remove options A & D from potential solutions. I know that lead is considered heavy, and as such I choose $11.0 g/cm^3$.

$\boxed{C.\ 11.0\,gcm^{-3}}$

② 60 Km/hr, 600 Km North is destination. How long?

$T = \frac{distance}{speed}$

$T = \frac{600km}{60\,Km\,hr^{-1}} = \boxed{10\text{ hours to reach Emoryville}}$

③ what's $25ms^{-1}$ in $Kmhr^{-1}$?

1 m/s = 3.6 Km/hr, so

$25\frac{m}{s} \times \left(\frac{3.6\,Km/hr}{m/s}\right) = \boxed{90\,Km/hr, D}$

?④ accelerates from 0 Km/hr → 10 Km/hr in 60s. acceleration = ?

$A = \frac{V_f - V_i}{T}$

$A = \frac{10\,km/hr - 0}{1/60\,hr} = \frac{10\,Km/h}{1/60\,hr} = \frac{600\,Kmh^{-2}}{3600\,seconds} = \frac{600}{60} = 10\,Kms^{-1}$

$\frac{10\,Km/h}{60\,s} = \boxed{1/6\,Km/h/s, C}$

(5) estimate the North Quad.

I would estimate it to be 5,000 m^2 (8/28 warmup?)

The other options are too small.

$\boxed{5{,}000 m^2, A}$

(6) coffee bean $= 0.5 cm^3$

how many in a 2L bottle? $N = \frac{2000 cm^3}{0.5 cm^3} = 4000 = \boxed{4 \times 10^3, C}$

$1L = 1000 cm^3$

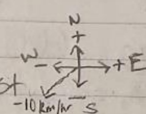
$2 \times 1000 = 2000 cm^3$

(7) $\vec{v} = v_x \hat{i} + v_y \hat{j}$

$v = 10$

wind $= 10 km hr^{-1}$ southwest

v_x & $v_y = ?$



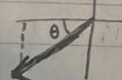
$\approx 225° = \frac{5\pi}{4}$ rad.

$v_x \hat{i} = v(\cos(225)) = 10 \cdot \cos(225) = -\frac{\sqrt{2}}{2}$

$v_y \hat{j} = 10(\sin(225)) = -\frac{\sqrt{2}}{2} \longrightarrow v_{x \& y} = 10\left(-\frac{\sqrt{2}}{2}\right) = -5\sqrt{2} = -7.07 km/hr$

$\boxed{v_x = v_y = -7.07 km hr^{-1}, D}$

(8) whats the angle the velocity makes w/ the x-axis?

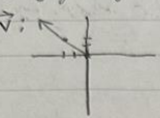


$\theta = 225°$ or $\frac{5\pi}{4}$ radians

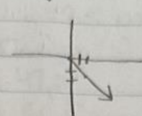
$\boxed{A, 225°}$

9 $\vec{v} = -2\hat{i} + 2\hat{j}$ $\vec{w} = 2\hat{i} - 2\hat{j}$

a $\vec{v}$:



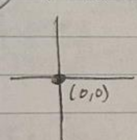
$\vec{w}$:



b $\vec{v} + \vec{w} = (-2\hat{i} + 2\hat{j}) + (2\hat{i} - 2\hat{j})$
$= (-2+2)\hat{i} + (2-2)\hat{j}$
$= 0\hat{i} + 0\hat{j}$
$\boxed{\vec{v} + \vec{w} = 0.}$

c $\vec{v} - \vec{w} = (-2\hat{i} + 2\hat{j}) - (2\hat{i} - 2\hat{j})$
$= (-2\hat{i} - 2\hat{i}) + (2\hat{j} + 2\hat{j})$
$= (-2-2)\hat{i} + (2+2)\hat{j}$
$\boxed{\vec{v} - \vec{w} = -4\hat{i} + 4\hat{j}}$

d $\vec{v} + \vec{w}$ and $\vec{v} - \vec{w}$



e $\vec{v} \cdot \vec{w}$
$\vec{v} \cdot \vec{w} = (-2\hat{i} + 2\hat{j}) \cdot (2\hat{i} - 2\hat{j})$
$= (-2+2) + (2-2)$
$= (-4) + (-4)$
$\boxed{\vec{v} \cdot \vec{w} = -8}$

Unit 1: (1-5)

1 $v_0 = 15 m/s$, $t = 0$, $a = 3ms^{-2}$

a velocity at $t = 4s$
$v = v_0 + at$
$v = 15\frac{m}{s} + (3\frac{m}{s^2} \times 4s)$
$\boxed{v = 27 ms^{-1}}$

b displacement (s) @ $t = 4s$
$s = v_0 t + \frac{1}{2}at^2$

$s = 15(4) + \frac{1}{2}(3)(4^2)$
$s = 60 + 0.5(3)(16) = \boxed{84 m}$

c average & instantaneous velocity
@ $t=0$, $v=15$ & $t=4$, $v=27$

instantaneous velocity when $t = 0s$ is $15ms^{-1}$ and when $t=4s$ is $27ms^{-1}$

av. velocity $= \frac{s}{t} = \frac{84m}{4s} = \boxed{21 ms^{-1}}$

② ⓐ speed from points P & Q

P(10,600) Q(25,2138)

speed p = $\frac{600m}{10s} = \boxed{60ms^{-1}}$

speed a = $\frac{2138m}{25s} = \boxed{85.52ms^{-1}}$

ⓑ is acceleration pos or neg. for the system?

$a = \frac{\Delta v}{\Delta t}$

$\Delta v = v_q - v_p = 85.52 - 60$

$\Delta v = 25.52 m/s$

$\Delta t = t_q - t_p = 25 - 10 = 15 m/s$

$a = \frac{25.52}{15} = \boxed{1.7 m/s^2}$

the acceleration of the system is positive

③ ⓐ $v = 6 m/s$

$a = .8 m/s^2$

$v^2 = v_0^2 + 2as$

$6^2 = 0^2 + 2(.8)s$

$\frac{36}{1.6} = \frac{1.6s}{1.6}$

$\boxed{s = 22.5m}$

ⓑ $v = v_0 + at$

$6 = 0 + (.8)t$

$t = \frac{6}{.8} = \boxed{7.5s}$

baseball

④ range = 60m

launch angle = ? ("perfect angle=45°) 30°

initial velocity = ? $26ms^{-1}$

time of flight = ?

$T = \frac{2v_0 \sin\theta}{g}$

$T = \frac{2(26)\sin 30°}{9.81}$

$T = \frac{26}{9.81} = \boxed{2.65s}$

*Verified in PhET Simulator, attatched.

$R = \frac{v_0^2 \sin(2\theta)}{g}$

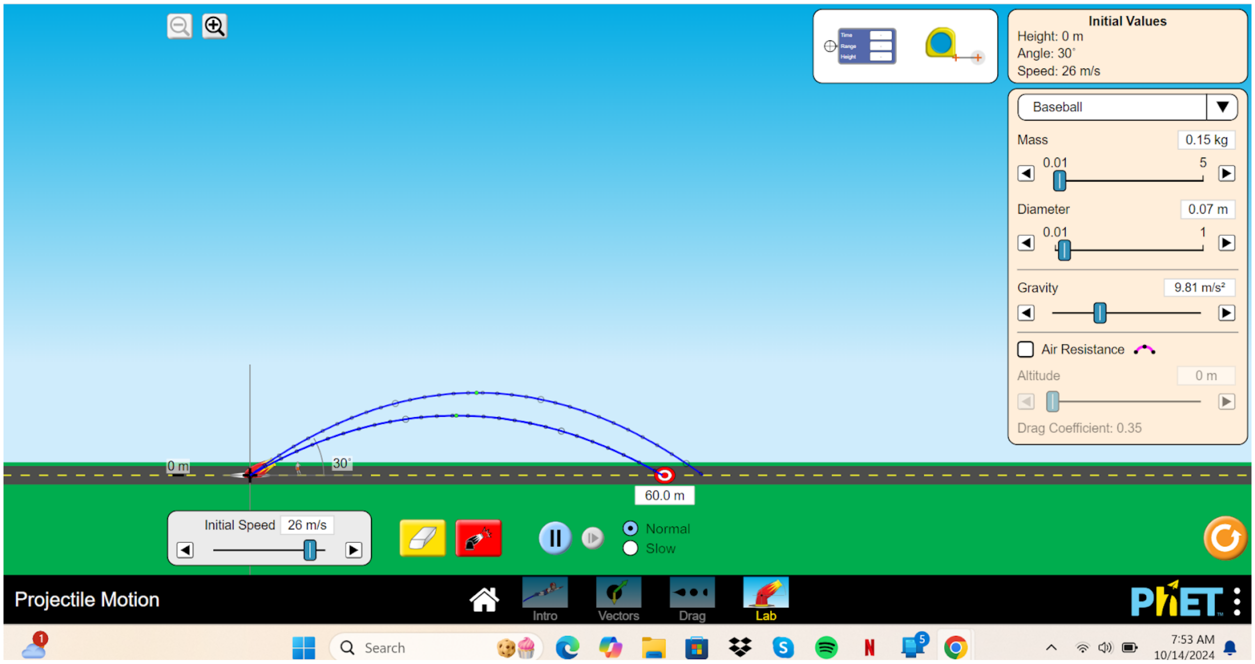
$60m = \frac{v_0^2 \sin(2 \cdot 30)}{9.81}$

$60m = \frac{v_0^2 \left(\frac{\sqrt{3}}{2}\right)}{9.81}$

$v_0^2 = \frac{60 \times 9.81}{\sqrt{3}/2} = \frac{588.6}{0.866} = 678.5$

$\sqrt{v_0^2} = \sqrt{678.5}$

$\boxed{v_0 = 26ms^{-1}}$



Initial Values
Height: 0 m
Angle: 30°
Speed: 26 m/s
Baseball
Mass
0.15 kg
0.01
5
Diameter
0.07 m
0.01
1
Gravity
9.81 m/s²
Air Resistance
Altitude
0 m
Drag Coefficient: 0.35
0 m
30°
60.0 m
Initial Speed
26 m/s
Normal
Slow
Projectile Motion
Intro
Vectors
Drag
Lab
PhET
Search
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(5) pendulum lab to measure g. $T = 2\pi\sqrt{L/g}$ (8/26 lab)

T = observed period, $g = 9.81\ ms^{-2}$ L = length (m)

mass = 1kg

starting angle 45°

trial#	length	time/period	Theory (s)	χ^2 (Chi^2)	error(s)
1	0.5m	1.39s	1.42s	0.0831	0.104
2	0.6m	1.54s	1.55s	0.00743	0.116
3	0.7m	1.76s	1.678s	0.386	0.132
4	0.75m	1.81s	1.74s	0.0049	0.136
5	0.8m	1.94s	1.79s	1.056	0.146
6	0.9m	1.98s	1.90s	0.288	0.149
7	1.0m	2.11s	2.005s	0.442	0.158

theory

$T = 2\pi(\sqrt{L/9.81})$

$= 2\pi(\sqrt{.5/9.81})$
$2\pi(\sqrt{.05096})$
$2\pi(0.2258)$
$= 1.42s$

$= 2\pi(\sqrt{.6/9.81})$
$= 2\pi(.2473)$
$= 1.55s$

$= 2\pi(\sqrt{.7/9.81})$
$= 2\pi(0.267)$
$= 1.678s$

$= 2\pi(\sqrt{.75/9.81})$
$= 1.743$

$= 2\pi(\sqrt{.8/9.81})$
$= 2\pi(0.285)$
$= 1.79s$

$= 2\pi(\sqrt{.9/9.81})$
$= 1.90s$

$= 2\pi(\sqrt{1.0/9.81})$
$= 2.005s$

Chi^2

error = period × 0.075

$\chi^2 = (\text{period} - \text{theory})^2 / \text{error}^2$

$\chi^2 = (1.39 - 1.42)^2 / 0.104^2$
$\chi^2 = (-0.03)^2 / 0.104^2$
$= 0.0009 / 0.010816$
$= 0.0831$

$= (1.54 - 1.55)^2 / 0.116^2$
$= 0.00743$

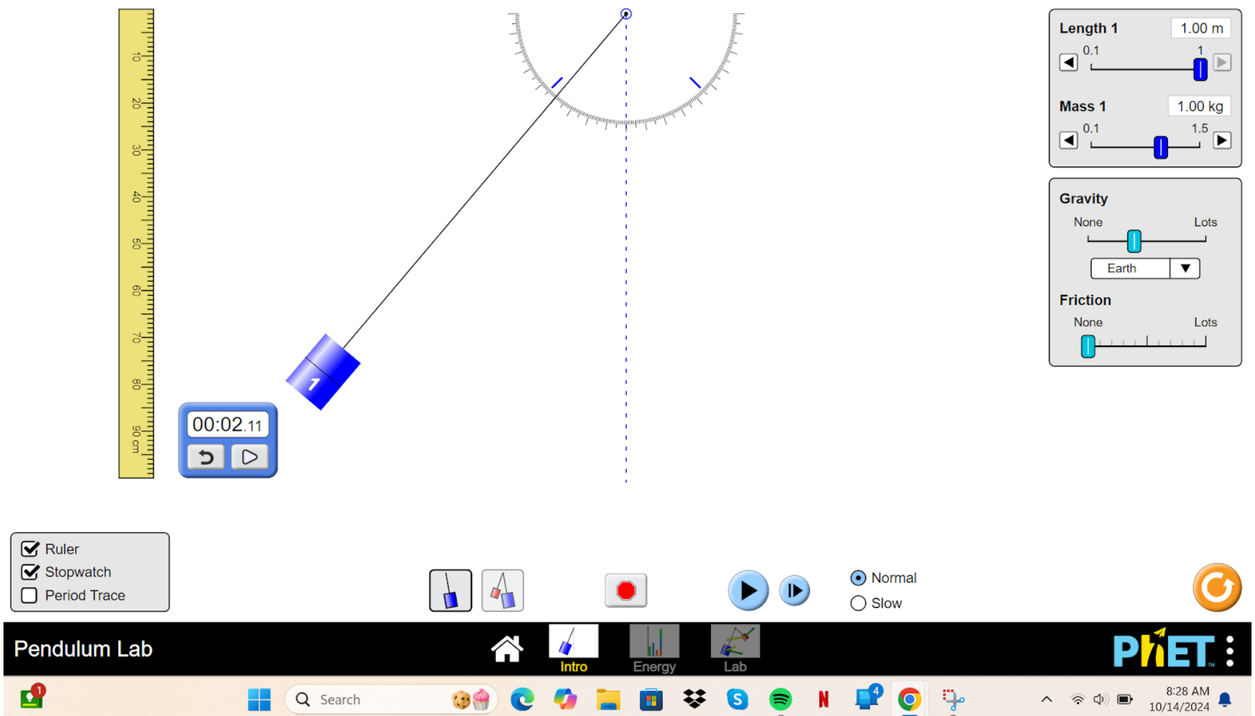
$= (1.76 - 1.678)^2 / 0.132^2$
$= 0.386$

$= (1.81 - 1.74)^2 / 0.136^2$
$= 0.0049$

$= (1.94 - 1.79)^2 / 0.146^2$
$= 1.056$

$= (1.98 - 1.9)^2 / 0.149^2$
$= 0.288$

$= (2.11 - 2.005)^2 / 0.158^2$
$= 0.442$



Length 1
1.00 m
Mass 1
1.00 kg
Gravity
None
Lots
Earth
Friction
00:02.11
Ruler
Stopwatch
Period Trace
Normal
Slow
Pendulum Lab
Intro
Energy
Lab
PhET
8:28 AM
10/14/2024

Unit 2: Forces I & II

① ⓐ $F_\perp = 1000N$, $7°$, Tension=?

$F_\perp = T\sin\theta$

$T = F_\perp / \sin\theta$

$T = \frac{1000N}{\sin(7)}$

$T = \frac{1000N}{0.12187} = \boxed{8205.5N}$

ⓑ acceleration=? m=900kg

$F = mg$

$F = 900(9.81)$

$F = 8829N$

$F_T = T\cos(\theta)$

$F_T = 8205.5(\cos(7))$

$F_T = 8154N$

$F_N = F_g - F_T$

$F_N = 8829 - 8154 = \boxed{675N}$

$\mu = 0.05$

$F_f = \mu \cdot F_N$

$F_f = 0.05(675N)$

$F_f = 33.75N$

$F_{net} = T - F_f$

$F_{net} = 8205.5 - 33.75$

$= 8171.75N$

$F_{net} = ma$

$\frac{F_{net}}{m} = a$

$a = \frac{8171.75}{900} = \boxed{9.08 m/s^2}$

② 20,000 kg

120 km/hr

Stops @ 100m

ⓐ av. acceleration?

$v_0 = \frac{120 km}{1 hr} = \frac{12000 m}{3600 sec} = 33.33 m/s$

$v^2 = v_0^2 + 2as$

$0^2 = (33.33)^2 + 2a(100)$

$0 = 1111.1 + 200a$

$200a = -1111.1$

$\boxed{a = -5.56 ms^{-2}}$

ⓑ force to stop?

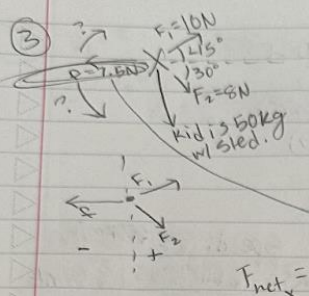
$F = ma$

$F = 20,000(-5.56)$

$\boxed{F = -111,200N}$

or 111,200N negative indicates opposite force applied to directon of jet.

3



acelleration = ?

- resolve into horiz. & vert.

$F_{1x} = 10N \cdot \cos 45°$
$= 7.07N$

$F_{2x} = 8 \cdot \cos 30$
$= 6.93N$

$F_{1y} = 10N \cdot \sin 45$
$= 7.07N$

$F_{2y} = 8 \cdot \sin 30$
$= 4N$

$F_{net_x} = 7.07 + 6.93 - 7.5N$

$F_{net\,x} = 6.5N$

$F_{net} = ma \quad m = 50kg$

$a = \frac{F}{m}$

$a = \frac{6.5N}{50kg} = 0.13ms^{-2}$

$\boxed{\text{acceleration} = 0.13ms^{-2}}$

Unit 3: Forces III & IV

?. 1

(a) $a = g(\sin\theta - \mu\cos\theta)$

since it's down an incline, g plays a factor. equation would stay the same: $\boxed{a = g(\sin\theta - \mu\cos\theta)}$

(b) $\mu \to 0$

as $\mu \to 0$ the $\mu\cos\theta$ part becomes super small and close to zero, so it'd just be $\boxed{a = g\sin\theta}$

2 (a) $a = g(\sin\theta - \mu\cos\theta)$

$\theta = 10°$

$g = 9.81$

wax & snow coeff: $\mu = 0.1$

$a = 9.81(\sin 10 - 0.1\cos 10)$

$a = 9.81(0.1736 - 0.0984)$

$\boxed{a = 0.737ms^{-2}}$

(b) how far and how fast after 30s?

$s = v_0 t + \frac{1}{2}at^2$

$s = 0t + \frac{1}{2}(.737)(30s)^2$

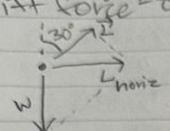
$s = 0.3685(900) = \boxed{331.65m}$

$v = v_0 + at$

$v = 0 + (.737)(30)$

$\boxed{v = 22.11ms^{-1}}$

3. 6000kg, $\theta = 30$
lift force = 80,000N



(a) centripetal force?
$F_c = L\sin\theta$
$F_c = 80{,}000\sin(30°)$
$= 80000(0.5)$
$\boxed{F_c = 40{,}000N}$

(b) turn radius?
$F_c = \frac{mv^2}{r}$
$r = \frac{mv^2}{F_c}$

$r = \frac{6000(166.67)^2}{40{,}000N}$

turn radius
$\boxed{r = 4166.67m}$

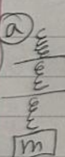
Speed: $v = 600km/hr$
$\frac{600 \times 1000}{3600} = 166.67m/s$

(c) time to turn around?
$C = 2\pi r$
$C = 2\pi(4166.67) = 26161.66m$ ← full circle

$d = \frac{C}{2} = \frac{26161.66}{2} = 13080.8m$

$t = \frac{d}{v} = \frac{13080.8}{166.67} = \boxed{78.49s}$

4. (a)



(b) $F_{total} = 3kx$ *Hooke's law
$mg = 3kx$
$\boxed{x = \frac{mg}{3k}}$
new expression

(c) $k \to \infty$ displacement (x) $\to 0$
$x = \frac{mg}{3k}$ as $k \to \infty$
$0 = x = \frac{mg}{3 \cdot \infty}$ x is = 0 because the infinity on the bottom makes it a super small fraction.

(5) $V_t = ?$, 60kg , $A = 0.25m^2$, $C = 0.5$, $\rho = 1.2 kg/m^3$

(a) $V_t = ?$

$V_t = \sqrt{\frac{2mg}{\rho C A}} = \sqrt{\frac{2(60)(9.81)}{1.2(.5)(.25)}}$

$= \sqrt{\frac{2 \times 588.6N}{0.15 kg/m}} = \sqrt{\frac{1177.2}{0.15}} = \sqrt{7848} = \boxed{88.6ms^{-1}}$

(b) $A \times 100$

$.25 \times 100 = 25m^2 = A$

Scaling problem.

$V_t = \sqrt{\frac{2(60)(9.81)}{1.2(.5)(25)}} = \sqrt{\frac{1177.2N}{15kg/m}} = \sqrt{78.48} = \boxed{8.85ms^{-1}}$

(6) (a) granite: $45 \times 10^9 Nm^{-2} = E$

$\Delta L = ?$ 10,000N $d = 20cm$, 10m tall

$\Delta L = \frac{FL}{AE}$ $A = \pi\left(\frac{d}{2}\right)^2$

$= \pi\left(\frac{.2}{2}\right)^2$

$A = 0.0314m^2$

$\Delta L = \frac{10000(10)}{0.0314(45 \times 10^9)} = \frac{100000}{1.43 \times 10^9} = 7.06 \times 10^{-5} m =$ $\boxed{\text{0.0706mm change in length}}$

(b) $45 \times 10^9 \div 2 = 22.5 \times 10^9$

$\Delta L = \frac{10000(10)}{22.5(10^9)(.0314)} = 1.415 \times 10^{-4} m =$ $\boxed{\text{0.1415mm in half of Young's new material length change}}$