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Department of Engineering Sciences
Phy101 Physics I
Midterm Examination
April 17, 2025 10:20 – 11:50
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

INSTRUCTOR:

DURATION: 90 minutes

◇ **Answer all the questions.**
◇ **Write the solutions explicitly and clearly. Use the physical terminology.**
◇ **You are allowed to use Formulae Sheet.**
◇ **Calculator is allowed.**
◇ **You are not allowed to use any other electronic equipment in the exam.**

Question	Grade	Out of
1A		10
1B		10
2		20
3		20
4		20
5		20
TOTAL		100

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1. A) A ball is directed downward with an initial velocity of $v = 2.0 \pm 0.1$ m/s. After a time t=0.40 ± 0.04 s is passed, the ball hits the ground. What is the initial height $y \pm \Delta y$ (both value and uncertainty)? Assume g=9.80 m/s^2 (no uncertainty)

$v = 2.0 \pm 0.1$ m/s downward (−)

$t = 0.40 \pm 0.04$ s

$g = 9.80$ m/s^2

$y_0 \pm \Delta y_0 \equiv ?$

$y - y_0 = -v_0 t - \frac{1}{2} g t^2$

$y = 0$ (ground): $y_0 = v_0 t + \frac{1}{2} g t^2$

$C = A + B$

$\Delta C = \sqrt{\Delta A^2 + \Delta B^2}$ (2)

$A = 0.80 \pm 0.09$ m

$B = 0.78 \pm 0.16$ m

$C \pm \Delta C$

$1.58 \pm \sqrt{(0.09)^2 + (0.16)^2}$ (2)

$y_0 \pm \Delta y_0 \rightsquigarrow \underline{\underline{1.58 \pm 0.18\,m}}$

A: $v_0 t \rightsquigarrow C' = A' * B' \rightsquigarrow \Delta C' = |C| \sqrt{\left(\frac{\Delta A}{A}\right)^2 + \left(\frac{\Delta B}{B}\right)^2}$ (2)

$v_0 t \to C' \to 0.80$

$\Delta C' = |0.80| \sqrt{\left(\frac{0.1}{2.0}\right)^2 + \left(\frac{0.04}{0.40}\right)^2} = \underline{0.09\,m}$ (1)

$\Rightarrow \underline{0.80 \pm 0.09\,m}$

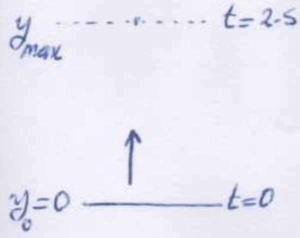
B: $\frac{1}{2} g t^2 \rightsquigarrow A' = B'^n \rightsquigarrow \Delta A' = B'^n |n| \frac{\Delta B'}{B'}$ (2)

$\frac{1}{2} g t^2 \to \frac{1}{2} g A'^2 \to 0.78$

$\Delta A' = 0.40^2 |2| \frac{0.04}{0.40} = \underline{0.03\,s}$ (1)

$0.78 \rightsquigarrow \underline{0.78 \pm 0.16}\ m$

B) A rock is thrown vertically upward from ground level at time $t = 0$ s. At $t = 1.5$ s it passes the top of a tall tower, and 1.0 s later it reaches its maximum height. What is the height of the tower?



at y_{max} (2) $\Rightarrow v_y = 0$

$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$ (1)

$v_y = v_{0y} - gt$ (1)

$\rightarrow 0 = v_{0y} - 9.8 m/s^2 (2.5 s)$ (1)

$v_{0y} = 24.5$ m/s (0.5) (0.5)

$\Rightarrow y(t = 1.5s)$: height of the tower

$y(t=1.5s) = y_0 + v_{0y}(1.5s) - \frac{1}{2}g(1.5s)^2$ (3)

$= 0 + (24.5 m/s)(1.5s) - (4.9 m/s^2)(1.5s)^2$

$= 25.725 m$ (0.5) (0.5) $\rightsquigarrow$ $\boxed{\text{height} \cong 26 m}$

2.

Two vectors are presented as:

$$\begin{aligned}\vec{a} &= 3.0\hat{i} + 5.0\hat{j},\\ \vec{b} &= 2.0\hat{i} + 4.00\hat{j}\end{aligned}$$

Find:

i $\vec{a} \times \vec{b}$,

ii $\vec{a} \cdot \vec{b}$,

iii $(\vec{a} + \vec{b}) \cdot \vec{b}$,

iv The component of $\vec{a}$ along the direction of $\vec{b}$. (Hint: $\hat{b} = \vec{b}/|\vec{b}|$))

$\vec{a} = 3.0\hat{i} + 5.0\hat{j}$

$\vec{b} = 2.0\hat{i} + 4.0\hat{j}$

i) $\vec{a} \times \vec{b}$ vector $\rightsquigarrow \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 5 & 0 \\ 2 & 4 & 0 \end{vmatrix} = \hat{i}(5*0 - 4*0) - \hat{j}(3*0 - 2*0) + \hat{k}(3*4 - 2*5) = \underline{\underline{2\hat{k}}}$ 5

ii) $\vec{a} . \vec{b}$ scalar $\rightsquigarrow 3*2 \underbrace{\hat{i}\cdot\hat{i}}_{1} + 5*4 \underbrace{\hat{j}\cdot\hat{j}}_{1} = \underline{\underline{26}}$ 5

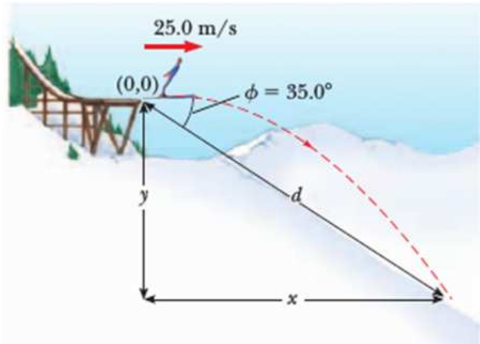
iii) $(\vec{a} + \vec{b}) \cdot \vec{b}$ scalar $\rightsquigarrow (5\hat{i} + 9\hat{j}) \cdot (2\hat{i} + 4\hat{j})$

$10 \underbrace{\hat{i}\cdot\hat{i}}_{1} + 36 \underbrace{\hat{j}\cdot\hat{j}}_{1} = \underline{\underline{46}}$ 5

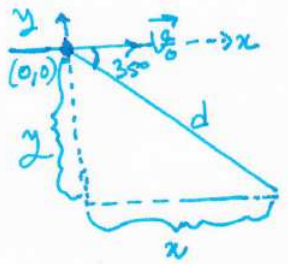
iv) $\hat{b} = \frac{\vec{b}}{|\vec{b}|} = \frac{2\hat{i} + 4\hat{j}}{\sqrt{2^2 + 4^2}} \rightsquigarrow a_b = \vec{a} \cdot \hat{b} = (3\hat{i} + 5\hat{j}) \cdot \frac{(2\hat{i} + 4\hat{j})}{\sqrt{20}}$

$= \frac{6\hat{i}\cdot\hat{i} + 20\hat{j}\cdot\hat{j}}{\sqrt{20}} = \underline{\underline{5.8}}$ 5

3. A ski jumper leaves the ski track moving in the horizontal direction with a speed of 25.0 m/s as shown in Figure. The landing incline below her falls off with a slope of 35.0°.



Where does she land on the incline?



$x = x_0 + v_{0x} t$

$y = y_0 + v_{0y} t - \frac{1}{2} g t^2$

$v_{0x} = v_0 \cos\theta$

$v_{0y} = v_0 \sin\theta$

$\theta = \phi$

$v_0 = 25.0\ m/s$ (2)

$\Delta x = d \sin 55° = v_0 \cos\phi\, t$ (3)

$\Delta y = -d \cos 55 = v_0 \cancel{\sin\phi\, t} - \frac{1}{2} g t^2$ (3)

$t = \frac{d \sin 55°}{v_0}$ (3)

$\Rightarrow d = \frac{1}{2\cos 55} (9.8\ m/s^2) \left(\frac{d \sin 55°}{v_0}\right)^2$

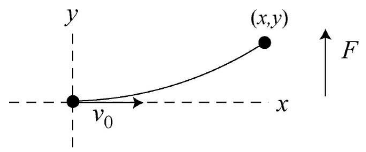
$\Rightarrow d = \frac{v_0^2}{(\sin 55)^2} \frac{2\cos 55}{(9.8\ m/s^2)} = \underline{109\ m}$ (3)

$\Rightarrow x_f - \cancel{x_i} = \Delta x = (109\ m) \sin 55 = \underline{89.3\ m}$ (2) (1)

$y_f - \cancel{y_i}^{\,0} = \Delta y = -(109\ m) \cos 55 = \underline{-62.5\ m}$ (2) (1)

(−)

4. An electron with a speed of $1.2 \times 10^{7}\ m/s$ moves horizontally into a region where a constant vertical force of $4.5 \times 10^{-16}\ N$ acts on it. The mass of the electron is $9.11 \times 10^{-31}\ kg$.



Determine the vertical distance the electron is deflected during the time it has moved 30 mm horizontally.

$v_0 = 1.2\times10^{7}\ m/s$

$F_y = 4.5\times10^{-16}\ N$

$m_e = 9.11\times10^{-31}\ kg$

$\Delta x = x - x_0 = 30\times10^{-3}\ m$

$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$

$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$

$v_x = v_{0x} + a_x t$

$v_y = v_{0y} + a_y t$

(1) $x - x_0 = v_{0x} t \sim a_x = \phi$

(2) $y - y_0 = \frac{1}{2} a_y t^2 \sim v_{0y} = \phi$

(3) $v_x = v_{0x} \sim a_x = \phi$

(4) $v_y = a_y t \sim v_{0y} = \phi$

(5) $F_y = m_e a_y$

5

(1) $t = \frac{x - x_0}{v_0}$ 5

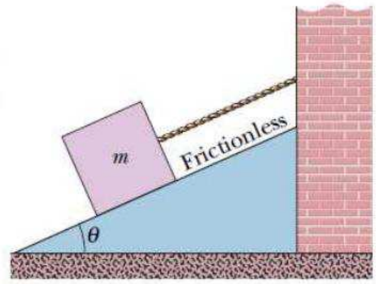
(2) (5) $y - y_0 = \frac{1}{2}\left(\frac{F_y}{m_e}\right)t^2 \rightarrow$ (1)(2)(5) $y - y_0 = \frac{1}{2}\frac{F_y}{m_e}\left(\frac{x - x_0}{v_0}\right)^2$

$\rightarrow y - y_0 = \frac{1}{2}\frac{4.5\times10^{-16}\ N}{9.11\times10^{-31}\ kg}\left(\frac{30\times10^{-3}\ m}{1.2\times10^{7}\ m/s}\right)^2 = 1.5\times10^{-3}\ m$

5 3 2

notice that $y \propto x^2$ parabolic path

5. In Figure, let the mass of the block be 8.5 kg and the angle be 30°.



Find:

i the tension in the cord.

ii the normal force acting on the block.

iii If the cord is cut, find the magnitude of the resulting acceleration of the block.

17) $m = 8.5\,kg$

$\theta = 30°$

i) $T = ?$ acceleration is zero

Newton 2nd law

x: ① $T - mg\sin\theta = ma_x = 0$ ②

y: $F_N - mg\cos\theta = ma_y = 0$ ② ②

① $T = (8.5\,kg)(9.8\,m/s^2)\sin 30° = 41.65\,N \to 42\,N$ ① ①

y, x, F_N, T, $mg\sin\theta$, $mg\cos\theta$, mg ④

FBD

ii) $F_N = ?$ ② ③ $F_N = mg\cos\theta = (8.5\,kg)(9.8\,m/s^2)\cos 30° = 72.14\,N \sim 72\,N$ ① ①

iii) cord is cut $\to a = ?$

$\cancel{T}^{\,0} - mg\sin\theta = ma_x \to a_x = a = -g\sin\theta$ ① ①

③ $= -(9.8\,m/s^2)\frac{1}{2} = -4.9\,m/s^2$

(−) ⇒ acceleration is downward. Also check $\theta = 90°$

no further contact with surface ⇐ $a = -g$

18) $W = 700\,kN$