İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy101 Physics I
Midterm Examination
November 20, 2024 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.**

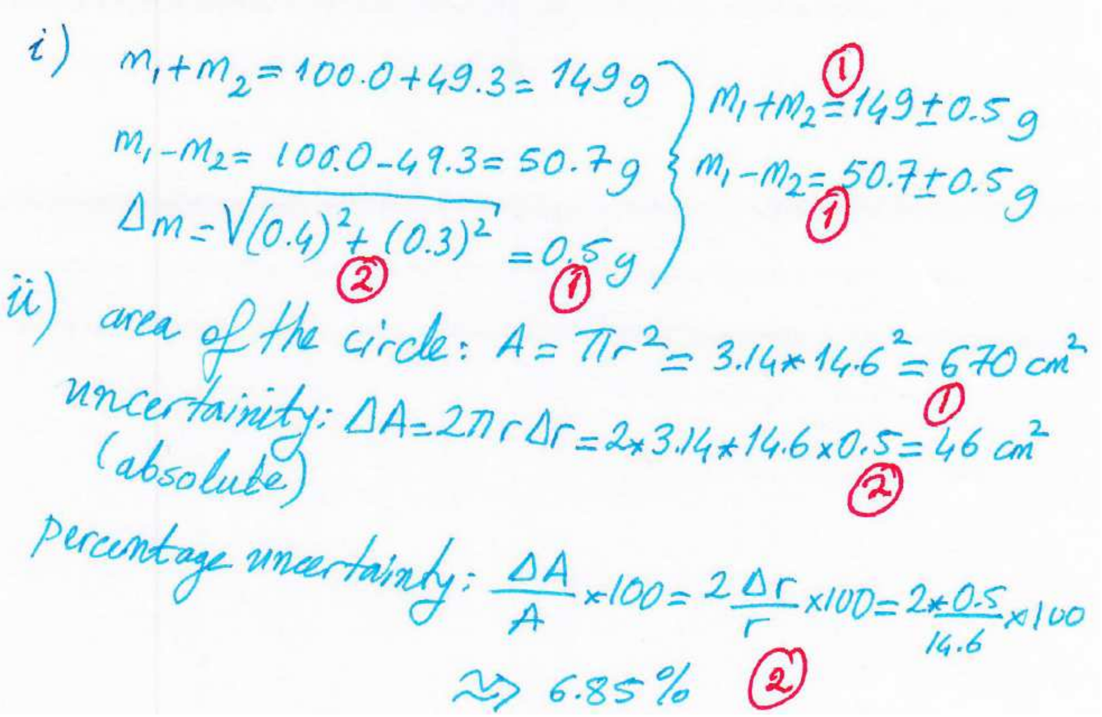
Question	Grade	Out of
1A		10
1B		10
2		20
3		20
4		20
5		20
TOTAL		100

This page is intentionally left blank. Use the space if needed.

1. A) i Given two masses, $m_1 = (100.0 \pm 0.4)\ g$ and $m_2 = (49.3 \pm 0.3)\ g$, what is their sum, $m_1 + m_2$, and what is their difference, $m_1 - m_2$, both expressed with uncertainties.

ii What is the absolute and percentage uncertainty in the calculated area of a circle whose radius is determined to be $r = (14.6 \pm 0.5)\ cm$? (Hint: $\Delta A = 2\pi r \Delta r$)

You should be using the correct number of significant figures in your result.



i) $m_1 + m_2 = 100.0 + 49.3 = 149\,g$

$m_1 - m_2 = 100.0 - 49.3 = 50.7\,g$

$\Delta m = \sqrt{(0.4)^2 + (0.3)^2} = 0.5\,g$ ② ①

① $m_1 + m_2 = 149 \pm 0.5\,g$

$m_1 - m_2 = 50.7 \pm 0.5\,g$ ①

ii) area of the circle: $A = \pi r^2 = 3.14 * 14.6^2 = 670\,cm^2$ ①

uncertainity: $\Delta A = 2\pi r \Delta r = 2 * 3.14 * 14.6 \times 0.5 = 46\,cm^2$ ②
(absolute)

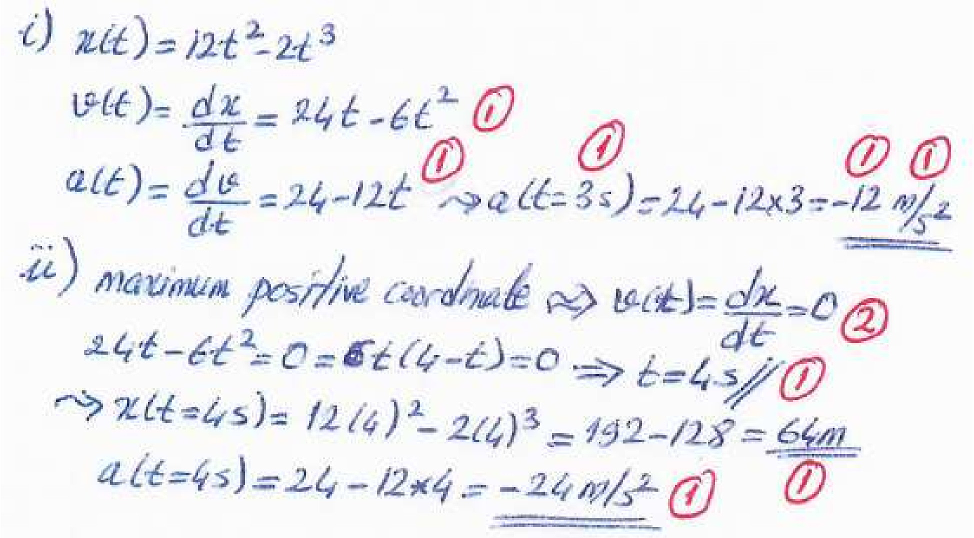
percentage uncertainty: $\frac{\Delta A}{A} \times 100 = 2\frac{\Delta r}{r} \times 100 = 2 * \frac{0.5}{14.6} \times 100$

$\rightsquigarrow$ 6.85 % ②

B) The position of a particle moving along an x-axis is given by $x(t) = 12t^2 - 2t^3$, where x is in meters and t is in seconds.

  i Determine the acceleration of the particle at $t = 3.0\ s$.

  ii What are the maximum positive coordinate reached by the particle and the acceleration of the particle at that instant?



i) $x(t) = 12t^2 - 2t^3$

$v(t) = \frac{dx}{dt} = 24t - 6t^2$ ①

$a(t) = \frac{dv}{dt} = 24 - 12t$ ① $\rightsquigarrow a(t=3s) = 24 - 12\times3 = \underline{\underline{-12\ m/s^2}}$ ① ① ①

ii) maximum positive coordinate $\Rightarrow v(t) = \frac{dx}{dt} = 0$ ②

$24t - 6t^2 = 0 = 6t(4-t) = 0 \Rightarrow t = 4s$ // ①

$\rightsquigarrow x(t=4s) = 12(4)^2 - 2(4)^3 = 192 - 128 = \underline{\underline{64m}}$ ①

$a(t=4s) = 24 - 12*4 = \underline{\underline{-24\ m/s^2}}$ ①

2.

Three vectors are given as:

$$\vec{A} = \hat{i} - 5\hat{k},$$
$$\vec{B} = 3\hat{i} - 2\hat{j},$$
$$\vec{C} = 5\hat{i} + \hat{j} + \hat{k}$$

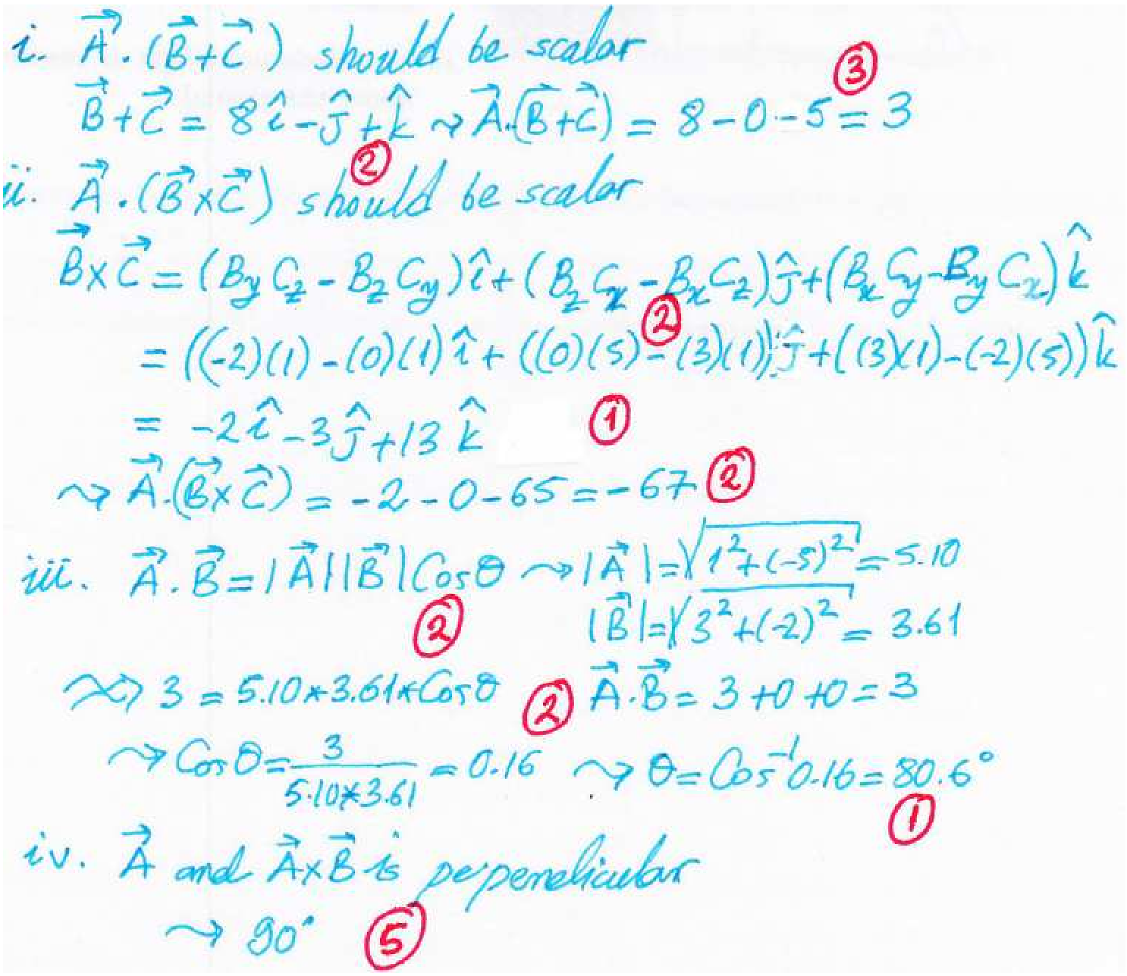
Find:

i $\vec{A}\cdot(\vec{B}+\vec{C})$,

ii $\vec{A}\cdot(\vec{B}\times\vec{C})$,

iii The angle between $\vec{A}$ and $\vec{B}$,

iv The angle between $\vec{A}$ and $\vec{A}\times\vec{B}$,



i. $\vec{A}.(\vec{B}+\vec{C})$ should be scalar

$\vec{B}+\vec{C} = 8\hat{i} - \hat{j} + \hat{k} \rightsquigarrow \vec{A}.(\vec{B}+\vec{C}) = 8-0-5 \overset{③}{=} 3$

ii. $\vec{A}.(\vec{B}\times\vec{C})$ ② should be scalar

$\vec{B}\times\vec{C} = (B_y C_z - B_z C_y)\hat{i} + (B_z C_x - B_x C_z)\hat{j} + (B_x C_y - B_y C_x)\hat{k}$

$= ((-2)(1) - (0)(1))\hat{i} + ((0)(5) \overset{②}{-} (3)(1))\hat{j} + ((3)(1) - (-2)(5))\hat{k}$

$= -2\hat{i} - 3\hat{j} + 13\hat{k}$ ①

$\rightsquigarrow \vec{A}.(\vec{B}\times\vec{C}) = -2-0-65 = -67$ ②

iii. $\vec{A}.\vec{B} = |\vec{A}||\vec{B}|\cos\theta \rightsquigarrow |\vec{A}| = \sqrt{1^2+(-5)^2} = 5.10$

② $|\vec{B}| = \sqrt{3^2+(-2)^2} = 3.61$

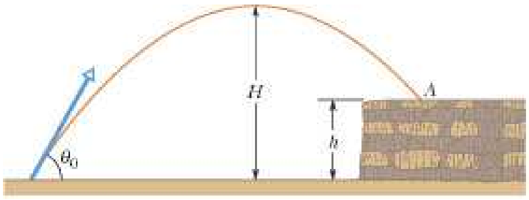
$\rightsquigarrow 3 = 5.10 * 3.61 * \cos\theta$ ② $\vec{A}.\vec{B} = 3+0+0 = 3$

$\rightsquigarrow \cos\theta = \frac{3}{5.10 * 3.61} = 0.16 \rightsquigarrow \theta = \cos^{-1} 0.16 = 80.6°$ ①

iv. $\vec{A}$ and $\vec{A}\times\vec{B}$ is pependicular

$\rightsquigarrow 90°$ ⑤

3. In figure given below, a stone is projected at a cliff of height h with an initial speed of $42.0\ m/s$ directed at angle $\theta_0 = 60°$ above the horizontal. The stone strikes point A in $5.50\ s$ after launching.



Find

i the height h of the cliff,

ii the speed of the stone hit at point A,

iii the maximum height H reached above the ground.

$v_0 = 42.0\,m/s$
$\theta_0 = 60°$
$t_A = 5.50\,s$

i) $y - y_0 = v_0 \sin\theta t - \frac{1}{2} g t^2$ ②

$h - \phi = (42\,m/s)\sin 60°(5.5s) - \frac{1}{2}(9.8\,m/s^2)(5.5s)^2$ ②

$\rightsquigarrow h = 51.8\,m$ ① ②

ii) ①

v at 5.5 s ?

$v = \sqrt{v_x^2 + v_y^2}$ ②

$v_x = v_{0x} = v_0 \cos\theta_0$

$v_y = v_0 \sin\theta_0 - gt$

$\rightsquigarrow \vec{v} = v_x \hat{i} + v_y \hat{j} = v_0 \cos\theta_0 \hat{i} + (v_0 \sin\theta_0 - gt)\hat{j}$ ②

$v(t = 5.5s) = \sqrt{v_0^2 \cos^2\theta_0 + (v_0 \sin\theta_0 - gt)^2}$ ②

$= \sqrt{(42\,m/s \cos 60)^2 + [42\,m/s \sin 60 - (9.8\,m/s^2)(5.5s)]^2} = 27.35\,m/s$ ① ①

iii) H ? at maximum height $v_y = 0$

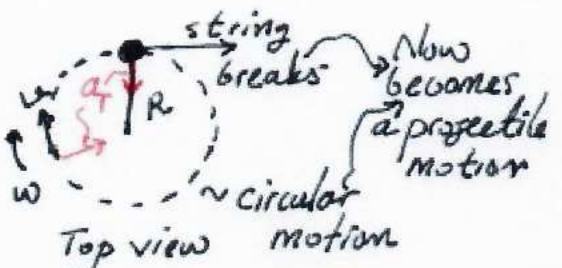
$v_y = v_0 \sin\theta_0 - gt = 0 \rightsquigarrow t_H = \frac{v_0 \sin\theta_0}{g} = \frac{(42\,m/s)(\sin 60°)}{9.8\,m/s^2} = 3.71\,s$ ① ①

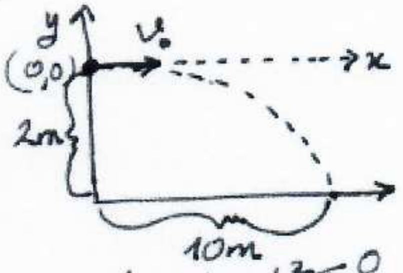
$\Rightarrow y - y_0 = H = v_0 \sin\theta_0 t_H - \frac{1}{2} g t_H^2$ ②

$= 42\,m/s \sin 60° \, 3.71s - \frac{1}{2} 9.8\,m/s^2 \, 3.71s^2$

$= 67.5\,m$ ① ①

4. A boy whirls a stone in a horizontal circle of radius 1.5 m and at height 2.0 m above level ground. The string breaks, and the stone flies off horizontally and strikes the ground after traveling a horizontal distance of 10 m. What is the magnitude of the centripetal acceleration of the stone during the circular motion?





Top view

$R = 1.5\,m$

$a_r = \frac{v^2}{R}\,,\; v = v_0 = ?$ ③

$\Rightarrow x - x_0 = v_0 t$ ②

$y - y_0 = -\frac{1}{2} g t^2$ ②

$10\,m = v_0 t$ ②

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

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 2m}{9.8\,m/s^2}} = 0.64\,s$ ② ①

$\Rightarrow v_0 = \frac{10\,m}{0.64\,s} = 15.65\,m/s$ ② ①

$x - x_0 = v_{0x} t \cancel{- \frac{1}{2} g t^2} \; a_x = 0$

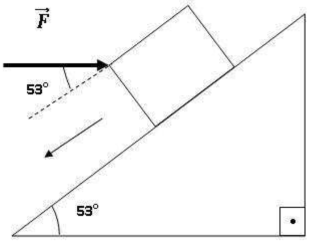
$y - y_0 = \cancel{v_{0y} t} - \frac{1}{2} g t^2 \; a_y$

$v_{0x} = v_0 \cos\theta_x = v_0 \sim \theta_x = 0$

$v_{0y} = v_0 \cos\theta_y = 0 \sim \theta_y = 90$

$a_r = \frac{(15.65\,m/s)^2}{1.5\,m} = 163.\bar{3}\,m/s^2$ ② ①

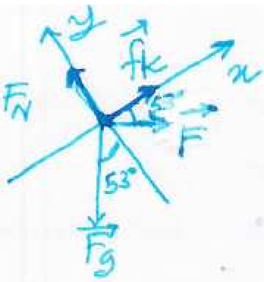
5. The block shown below moves down at a constant speed. If the block has a mass of 26 kg and the coefficients of kinetic (μ_k) and static (μ_s) frictions are 0.3 and 0.4, respectively;



i Draw free body diagram for the block,

ii Determine the magnitude of applied force.

i)



⑤

ii) Equations of motion
Newton's 2nd Law
$\Sigma F_x = ma_x$ & $\Sigma F_y = ma_y$
1 mass 2 directions: 2 eqns

① x: $f_k + F\,\mathrm{Cos}53 - mg\,\mathrm{Sin}53 = ma_x = 0$ ③ ① constant speed, $a_x = 0$

② y: $F_N - F\,\mathrm{Sin}53 - mg\,\mathrm{Cos}53 = ma_y = 0$ ③ ① no motion at y, $a_y = 0$

③ $f_k = \mu_k F_N$ ②

⇝ ② → $F_N = F\,\mathrm{Sin}53 + mg\,\mathrm{Cos}53$

② & ③ → $\mu_k(F\,\mathrm{Sin}53 + mg\,\mathrm{Cos}53) + F\,\mathrm{Cos}53 - mg\,\mathrm{Sin}53 = 0$

$$F = \frac{mg\,\mathrm{Sin}53 - \mu_k mg\,\mathrm{Cos}53}{\mu_k \mathrm{Sin}53 + \mathrm{Cos}53} = \frac{26kg\overset{9.8m/s^2}{\vee}\mathrm{Sin}53 - (0.3)26kg(9.8m/s^2)\mathrm{Cos}53}{(0.3)\mathrm{Sin}53 + \mathrm{Cos}53}$$ ③

$\cong 187.2\,N$
① ①