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Department of Engineering Sciences
Phy101 Physics I
Midterm Examination
April 07, 2019 10:30 – 12:30
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

DURATION: 120 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		15
1B		15
2		20
3		20
4		20
5		20
TOTAL		110

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1. A) Estimate the number of breaths taken during an average life time. (Hints: YOU estimate; the typical life time, the average number of breaths that a person takes in 1 min. Use chain rule. Use scientific notation in your final result.)

Typical life span is 70 years.

(2pt (estimation)) 10 breathes per minute is the average number for all situations which contain exercising, angry, sleeping, serene & so forth.

(Conversion by chain : 10 pt)

The # of minutes per year:

$$1\,yr \times 400\,\frac{days}{yr} \times \frac{25\,h}{day} \times 60\,\frac{min}{h} = 6\times10^{5}\,min$$

(To multiply 400×25 is simpler than 365×24 !)

$$(70\,yr)(6\times10^{5}\,min/yr) = 4\times10^{7}\,min$$

At a rate of 10 breathes/min, an individual would take 4×10^{8} breathes in a lifetime. (3pt)

B) The radius of a solid sphere is measured to be $(13.00 \pm 0.40)\ cm$, and its mass is measured to be $(3.70 \pm 0.04)\ kg$. Determine the density of the sphere in kilograms per cubic meter and the uncertainty in the density.

$R = (6.50 \pm 0.20)\,cm = (6.50 \pm 0.20) \times 10^{-2}\,m$

$m = (1.85 \pm 0.02)\,kg$ (3 sig figs)

$\rho = \frac{m}{V} = \frac{m}{\frac{4}{3}\pi R^3}$ (1) — Three steps

1st step: Raised to a power $C = A^n \;\&\; \Delta C = C\,|n|\,\frac{\Delta A}{A}$ (2)

$C = R^3 \rightsquigarrow \Delta C = R^3 |3| \frac{\Delta R}{R} = (2.75 \times 10^{-4}\,m^3)\,|3|\,\frac{0.20 \times 10^{-2}\,m}{6.50 \times 10^{-2}\,m}$

$= (6.50 \times 10^{-2}\,m)^3$

$= 2.75 \times 10^{-4}\,m^3$

$= 2.54 \times 10^{-5}\,m^3$

$\Longrightarrow (2.75 \times 10^{-4} \pm 2.54 \times 10^{-5})\,m^3$ (2)

2nd step: Multiplication with a scalar (2)

$\frac{4}{3}\pi\,(2.75 \times 10^{-4} \pm 2.54 \times 10^{-5})\,m^3 = (1.15 \times 10^{-3} \pm 1.06 \times 10^{-4})\,m^3$

3rd step: Multiplication/Division $C = \frac{A}{B} \;\&\; \Delta C = |C|\sqrt{\left(\frac{\Delta A}{A}\right)^2 + \left(\frac{\Delta B}{B}\right)^2}$ (2)

$\frac{(1.85 \pm 0.02)\,kg}{(1.15 \times 10^{-3} \pm 1.06 \times 10^{-4})\,m^3} \Rightarrow C = \frac{1.85\,kg}{1.15 \times 10^{-3}\,m^3} \;\&\; \Delta C = |1.61 \times 10^{3}\,kg/m^3|\sqrt{\left(\frac{0.02}{1.85}\right)^2 + \left(\frac{1.06 \times 10^{-4}}{1.15 \times 10^{-3}}\right)^2}$

$= 1.61 \times 10^{3}\,kg/m^3 \qquad = 0.149 \times 10^{3}\,kg/m^3$ (3)

$\Longrightarrow \boxed{(1.61 \pm 0.15) \times 10^{3}\,kg/m^3} \rightsquigarrow (1.6 \pm 0.2) \times 10^{3}\,kg/m^3$ (1) (2)

2. A physics book is dropped from a bridge, falling 90 m to the valley below the bridge.

   i In how much time does it pass through the last 20% of its fall?

   ii What is its speed when it begins that last 20% of its fall?

   iii What is its speed when it reaches the valley beneath the bridge?

$y - y_0 = -\frac{1}{2} g t^2$ (3) } Thus the time for full fall is found to be $t = 4.29$ s.

$y - y_0 = -90$ m (2)

because upward is chosen as (+) y direction!

The first 80% of its free-fall distance is given by $-72 = -g\tau^2/2$, which requires $\tau = 3.83$ s. (2)

a) Thus, the final 20% of its fall takes

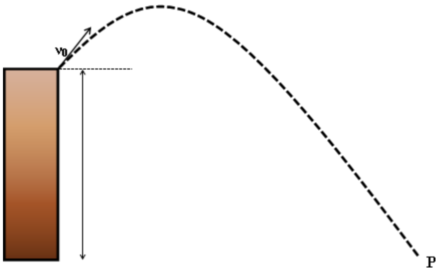
$t - \tau = 0.45$ s (3)

b) the speed $v = -g\tau$. (3)

$|v| = 38$ m/s approximately. (2)

c) Similarly, $v_{final} = -gt$ (3) $\Rightarrow |v_{final}| = 42$ m/s (2)

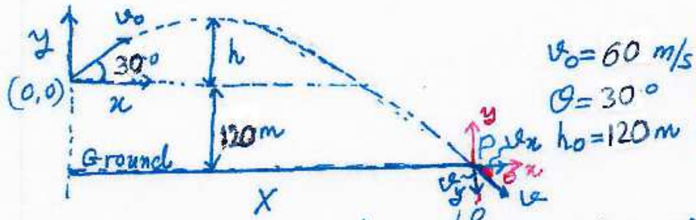
3. A projectile is shot from the edge cliff 120 m above ground level with an initial speed of 60 m/s at an angle of 30° with the horizontal.



i Determine the distance X of point P from the base of the vertical cliff.

ii What is the velocity v at point P in magnitude-angle notation and in unit-vector notation?

iii Find the maximum height reached by projectile **above ground**.



$v_0 = 60\ m/s$, $\theta = 30°$, $h_0 = 120\ m$ | $v_{0x} = v_0 \cos\theta$, $v_{0y} = v_0 \sin\theta$, $\sin 30 = 0.5$, $\cos 30 = 0.87$

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

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

$\Rightarrow x - x_0 = v_0 \cos\theta\, t$

$X = (60\ m/s) \cos 30\ (8.88\ s)$ (1)

$\cong 461\ m$ (1) (1)

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

$-120\ m = (60\ m/s) \sin 30°\, t - \frac{1}{2}\, 9.8\ m/s^2\, t^2$ (1)

$\Rightarrow 4.9 t^2 - 30\, t - 120 = 0$

$t_{1,2} = \dfrac{-(-30) \pm \sqrt{(-30)^2 - 4(4.9)(-120)}}{2(4.9)}$ (2)

$t_1 = -2.76\ s$ → not physical ← minus sign

$t_2 = 8.88\ s = t$ (1)

ii) At point P

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

$v_y = v_{0y} - g t = v_0 \sin\theta - g t$

$v_x = (60\ m/s) \cos 30°$ (1)

$v_y = (60\ m/s) \sin 30° - (9.8\ m/s^2)(8.88\ s)$ (1)

$v_x \cong 52\ m/s$ & $v_y = -57\ m/s$

$\vec{v} = v_x \hat{i} + v_y \hat{j} = (52\,\hat{i} - 57\,\hat{j})\ m/s$ (1) (1)

$\rightarrow |\vec{v}| = \sqrt{(52\ m/s)^2 + (-57\ m/s)^2}$

(1) $= 77.16\ m/s$, $\theta = \tan^{-1} \frac{-60.7}{53.2}$

$\cong -48°$ (1)

iii) $h_{max} = h_0 + h$ → What is h?

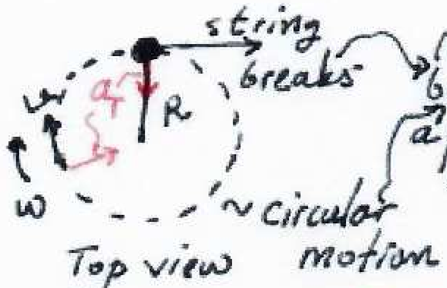
$v_y = v_{0y} - g t = 0$ at max height (2)

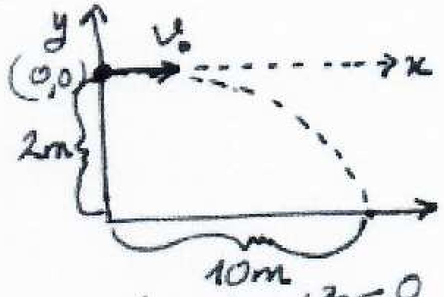
$t_f = \frac{v_{0y}}{g} \rightarrow h = v_{0y} \frac{v_{0y}}{g} - \frac{1}{2} g \left(\frac{v_{0y}}{g}\right)^2$

$h = \frac{1}{2} \frac{v_0^2 \sin^2\theta}{g}$ (2) $= \frac{1}{2} (60\ m/s)^2 \frac{\sin^2 30°}{9.8\ m/s^2}$

$h \cong 46\ m$ (1) $\Rightarrow h_{max} = 120\ m + 46\ m$ (1) $= 166\ m$

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?





$R = 1.5\,m$

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

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

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

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

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

$\Rightarrow x - x_0 = v_0 t$ (2)

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

$10\,m = v_0 t$ (2)

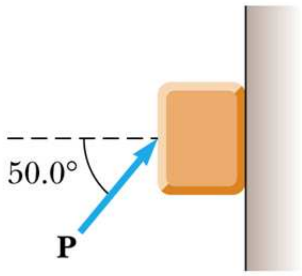
$-2m = -\frac{1}{2}(9.8\,m/s^2)\,t^2$ (2)

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

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

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

5. A block of mass 3.00 kg is pushed up against a wall by a force P that makes a 50.0° angle with the horizontal as shown in Figure below. The coefficient of static friction between the block and the wall is 0.250.



Determine minimum and maximum values for the magnitude of P that allow the block to remain stationary.