İZMİR KATİP ÇELEBİ UNIVERSITY	FACULTY OF ENG. & ARCH. PHY101, MIDTERM EXAM 13 November 2018, 16:30, DURATION: 120 MIN			
Student Name	**ID Number**	**Instructor Name**	**Department**	**Signature**

Please read the following directions carefully.

- You must show all your work to get credit; you will not be given any points unless you show the details of your work (this applies even if your final answer is correct).
- Write neatly and clearly; unreadable answers will not be given any credit. If you need more writing space, use the backs of the question pages and put down the appropriate pointer marks.
- Make sure that you include units in your results. Incomplete calculations will not be graded.
- Turn off your mobile phones, and put away. No notebooks or textbooks are allowed to use during the exam.
- You are not allowed to leave the class during the first 15 minutes, and last 15 minutes.
- Calculator is allowed to use. Calculator is assumed to be used only for simple arithmetics, other intentions will be considered as cheating. Everybody must use his/her own calculator. Do not exchange calculators during the exam!
- There are 8 questions. Grade point values are under question numbers.
- Before you begin, please check all pages.
- At the end of the exam make sure that you turn in your exam paper to your proctor by yourself! Do not give your exam paper to others!

1 (10pts)	2 (15pts)	3 (15pts)	4 (10pts)	5 (10pts)	6 (15pts)	7 (10pts)	8 (15pts)	Total grade

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This page can be used if necessary.

QUESTIONS
(Put your solutions under each question!)

1. You buy an object with a weight of 28.9 piculs in the local unit of weights: 1 picul=100 gins, 1 gin=16 tahils, 1 tahil=10 chees, and 1 chee=10 hoons in Malaysia. The weight of 1 hoon corresponds to a mass of 0.3779 g. How much mass of object in kilograms? Solve by using chain-link conversions explicitly and express your final result with 3 significant figures.

$$28.9\ \text{piculs}\ \frac{100\ \text{gins}}{1\ \text{picul}}\ \frac{16\ \text{tahils}}{1\ \text{gin}}\ \frac{10\ \text{chees}}{1\ \text{tahil}}\ \frac{10\ \text{hoons}}{1\ \text{chee}}\ \frac{0.3779\ \text{g}}{1\ \text{hoon}}\ \frac{1\ \text{kg}}{1000\ \text{g}} = 1747.4096\ \text{kg}$$

(5)

$\rightsquigarrow$ $\boxed{1.75 \times 10^{3}\ \text{kg}}$ (5)

2. A) A ball is released from the rest at an initial height and is in free fall. After a time t=0.40∓0.04 s is passed, the ball hits the ground. What is the velocity v∓Δv at impact (both value and uncertainty)? Assume g=9.80 m/s^2 (no uncertainty)

   B) A ball is released from the rest at an initial height and is in free fall. After a time t=0.40∓0.04 s is passed, the ball hits the ground What is the initial height y∓Δy (both value and uncertainty)? Assume g=9.80 m/s^2 (no uncertainty)

   C) A ball is directed downward with an initial velocity of v=2.0∓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∓Δy (both value and uncertainty)? Assume g=9.80 m/s^2 (no uncertainty)

Hints: A=cB → ΔA=|c| ΔB, A=B^n→ ΔA=B^n |n| B/ΔB, C=A+B→ ΔC=√(ΔA^2+ΔB^2), C=A*B→ ΔC=|C| √((ΔA/A)^2+(ΔB/B)^2).

A) released $v_0=0$, $v = v_0 - gt = gt = (9.8\,m/s^2)(0.40 \pm 0.04\,s)$ (−) shows direction

$A = cB$, $\Delta A = |c|\Delta B$ ③ $= 3.92 \pm 0.392 = 3.9 \pm 0.4\ m/s$ ① ①

B) released $v_0 = 0$ & $y - y_0 = v_0 t - \frac{1}{2}gt^2 \to -y_0 = -\frac{1}{2}gt^2 \to y_0 = \frac{1}{2}gt^2$ (ground 0)

$A = B^n$, $\Delta A = B^n |n| \frac{B}{\Delta B}$ $0.40^2 \pm 0.40^2 |2| \frac{0.04}{0.4} = 0.16 \pm 0.03\ s \to y_0 = 0.784 \pm 0.1568$ ③ $= 0.78 \pm 0.16$ ① ①

C) $v_0 = 2.0 \pm 0.1\,m$ & $t = 0.40 \pm 0.04\,s$ $\to y - y_0 = -v_0 t - \frac{1}{2}gt^2 \to y_0 = v_0 t + \frac{1}{2}gt^2$

$C = A + B$, $\Delta C = \sqrt{\Delta A^2 + \Delta B^2}$ $v_0 t = 0.80 \pm \left(|0.80|\sqrt{\left(\frac{0.1}{2.0}\right)^2 + \left(\frac{0.04}{0.40}\right)^2}\right) = 0.80 \pm 0.09\ m$ ②

$C = A * B$, $\Delta C = |C|\sqrt{\left(\frac{\Delta A}{A}\right)^2 + \left(\frac{\Delta B}{B}\right)^2}$ $v_0 t + \frac{1}{2}gt^2 = (0.80 \pm 0.09\,m) + (0.78 \pm 0.16) = 1.58 \pm \sqrt{(0.09^2) + (0.16^2)}$ ②

$y_0 = 1.58 \pm 0.18\ m$ ①

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3. A particle moves along the x axis. Its position is given by the equation x= 2 + 3t -4 t^2 with x in meters and t in seconds.Determine (a) its position when it changes direction and (b) its velocity when it returns to the position it had at t = 0.

(a) Compare the position equation $x = 2.00 + 3.00t - 4.00t^2$ to the general form

$$x_f = x_i + v_i t + \frac{1}{2}at^2$$

to recognize that $x_i = 2.00$ m, $v_i = 3.00$ m/s, and $a = -8.00$ m/s^2. The velocity equation, $v_f = v_i + at$, is then

$$v_f = 3.00 \text{ m/s} - (8.00 \text{ m/s}^2)t.$$

The particle changes direction when $v_f = 0$, which occurs at $t = \frac{3}{8}$ s. The position at this time is:

$$x = 2.00 \text{ m} + (3.00 \text{ m/s})\left(\frac{3}{8}\text{ s}\right) - (4.00 \text{ m/s}^2)\left(\frac{3}{8}\text{ s}\right)^2 = \boxed{2.56 \text{ m}}.$$

(b) From $x_f = x_i + v_i t + \frac{1}{2}at^2$, observe that when $x_f = x_i$, the time is given by $t = -\frac{2v_i}{a}$. Thus, when the particle returns to its initial position, the time is

$$t = \frac{-2(3.00 \text{ m/s})}{-8.00 \text{ m/s}^2} = \frac{3}{4}\text{ s}$$

and the velocity is $v_f = 3.00 \text{ m/s} - (8.00 \text{ m/s}^2)\left(\frac{3}{4}\text{ s}\right) = \boxed{-3.00 \text{ m/s}}$.

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4. A student throws a set of keys vertically upward to her sister, who is in a window 4.00 m above. The keys are caught 1.50 s later by the sister's hand. (a) With what initial velocity were the keys thrown? (b) What was the velocity of the keys just before they were caught? Take g=9.80 m/s²

(a) $y_f - y_i = v_i t + \frac{1}{2}at^2$: $4.00 = (1.50)v_i - (4.90)(1.50)^2$ and $v_i = \boxed{10.0 \text{ m/s upward}}$.

4

1

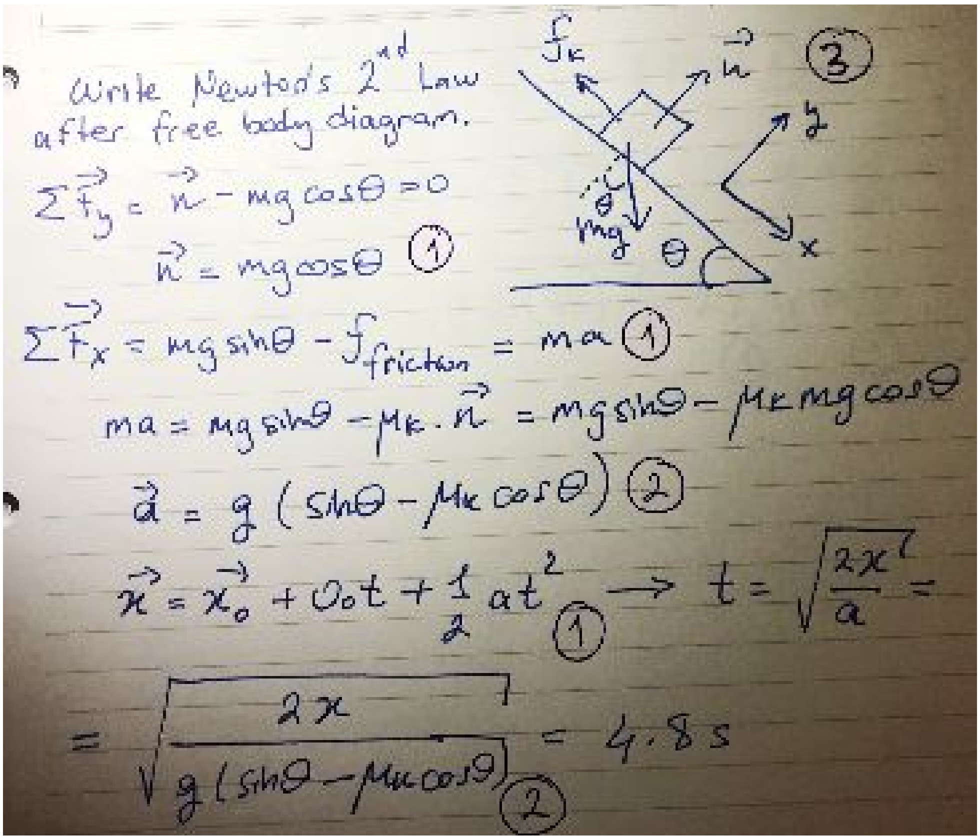
(b) $v_f = v_i + at = 10.0 - (9.80)(1.50) = -4.68 \text{ m/s}$

4

$v_f = \boxed{4.68 \text{ m/s downward}}$

1

5. A wet bar of soap slides down a ramp 9.0 m long inclined at 8.0°. How long does it take to reach the bottom? Draw free body diagram. Assume $\mu_k = 0.060$. Take g=9.80 m/s^2


Write Newton's 2nd Law after free body diagram.

$\sum \vec{F}_y = \vec{n} - mg\cos\theta = 0$

$\vec{n} = mg\cos\theta$ (1)

$\sum \vec{F}_x = mg\sin\theta - f_{friction} = ma$ (1)

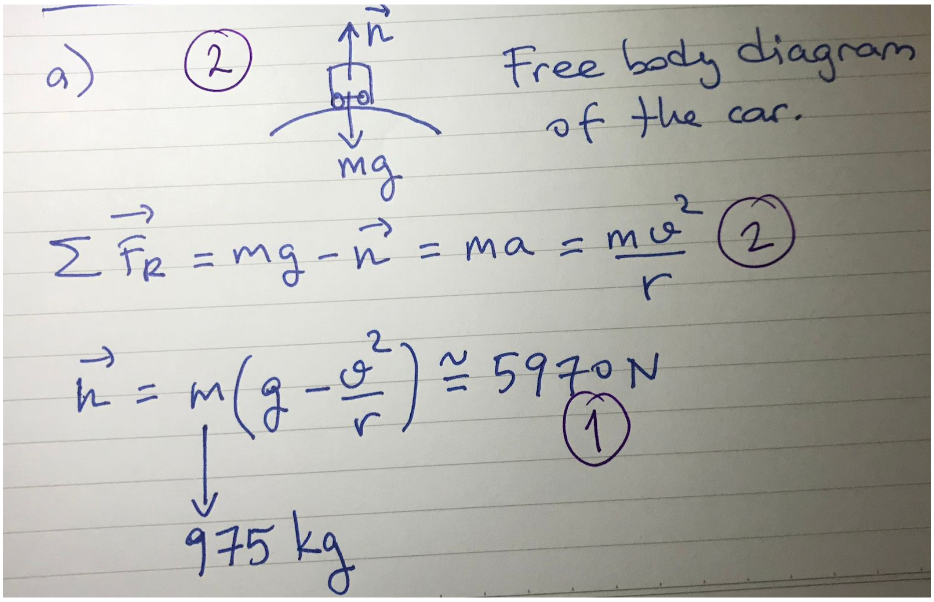
$ma = mg\sin\theta - \mu_k \cdot \vec{n} = mg\sin\theta - \mu_k mg\cos\theta$

$\vec{a} = g(\sin\theta - \mu_k\cos\theta)$ (2)

$\vec{x} = \vec{x}_0 + v_0 t + \frac{1}{2}at^2$ (1) $\rightarrow t = \sqrt{\frac{2x}{a}} =$

$= \sqrt{\frac{2x}{g(\sin\theta - \mu_k\cos\theta)}} = 4.8\text{ s}$ (2)

6. A 975-kg sports car (including driver) crosses the rounded top of a hill (radius = 88.0 m) at 18.0 m/s. Determine (a) the normal force exerted by the road on the car,
(b) the normal force exerted by the car on the 62.0-kg driver, and
(c) the car speed at which the normal force on the driver equals zero.
Take g=9.80 m/s^2



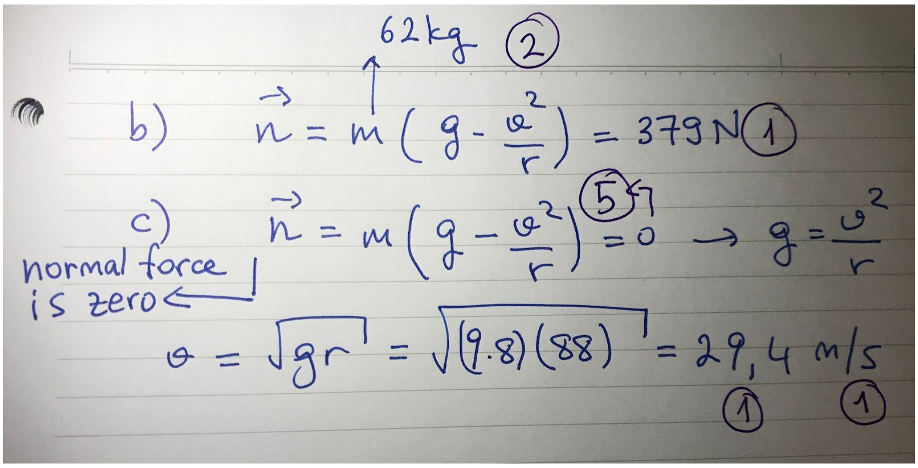
a) (2)

Free body diagram of the car. ($\vec{n}$ up, mg down)

$$\sum \vec{F}_R = mg - \vec{n} = ma = \frac{mv^2}{r} \quad (2)$$

$$\vec{n} = m\left(g - \frac{v^2}{r}\right) \cong 5970\,N \quad (1)$$

m → 975 kg



b) $\vec{n} = m\left(g - \frac{v^2}{r}\right) = 379\,N$ (1)   (m → 62 kg (2))

c) $\vec{n} = m\left(g - \frac{v^2}{r}\right) = 0 \rightarrow g = \frac{v^2}{r}$ (5)

normal force is zero

$$v = \sqrt{gr} = \sqrt{(9.8)(88)} = 29,4\ m/s$$ (1) (1)

7. A particle moves in the xy plane with constant acceleration. At time zero, the particle is at x =4 m, y = 3 m and has velocity vector $\boldsymbol{v}$ = (2 m/s) $\boldsymbol{i}$ + (-9 m/s) $\boldsymbol{j}$. The acceleration vector is given by $\boldsymbol{a}$ = (4 m/s^2) $\boldsymbol{i}$ + (3 m/s^2) $\boldsymbol{j}$. Calculate the velocity vector, in unit vector notation, at t = 2 s. Calculate the position vector, in unit vector notation, at t = 4 s. Calculate the magnitude and direction angle (relative to the +x-axis) of the position vector at t=4 s.

(*a*) The velocity of the particle, as a function of time, is given by:

$$\vec{v} = \vec{v}_0 + \vec{a}t$$ 2

Substitute to find the velocity at $t = 2$ s:

2

$$\vec{v} = (2\ \text{m/s})\hat{i} + (-9\ \text{m/s})\hat{j} + \left[(4\ \text{m/s}^2)\hat{i} + (3\ \text{m/s}^2)\hat{j}\right](2\text{s}) = \boxed{(10\ \text{m/s})\hat{i} + (-3\ \text{m/s})\hat{j}}$$

(*b*) Express the position vector as a function of time:

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$ 2

Substitute and simplify:

2

$$\vec{r} = (4\ \text{m})\hat{i} + (3\ \text{m})\hat{j} + \left[(2\ \text{m/s})\hat{i} + (-9\ \text{m/s})\hat{j}\right](4\ \text{s}) + \tfrac{1}{2}\left[(4\ \text{m/s}^2)\hat{i} + (3\ \text{m/s}^2)\hat{j}\right](4\ \text{s})^2 = \boxed{(44\ \text{m})\hat{i} + (-9\ \text{m})\hat{j}}$$

Find the magnitude and direction of $\vec{r}$ at $t = 4$ s:

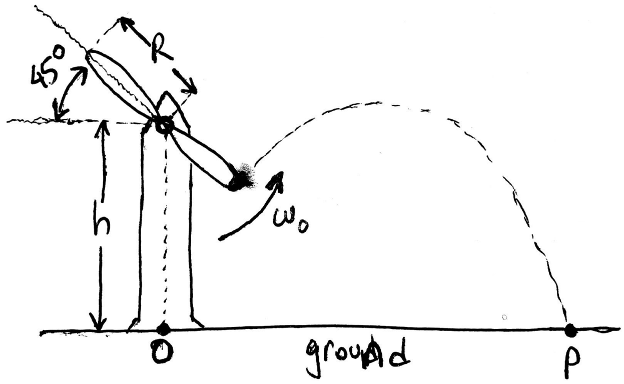
2

$$r(4\ \text{s}) = \sqrt{(44\ \text{m})^2 + (-9\ \text{m})^2} = \boxed{44.9\ \text{m}}$$

and, because $\vec{r}$ is in the 4th quadrant,

$$\theta = \tan^{-1}\left(\frac{-9\ \text{m}}{44\ \text{m}}\right) = \boxed{-11.6°}$$

8. A windmill is rotating with a constant angular speed of $\boldsymbol{\omega_0=\pi/4}$ rad/s in the counterclockwise direction. A small object at the tip of the propeller is parted when the propeller makes 45° angle and it goes into a projectile motion as shown in the figure. The height h to the center of the propeller is 20 m and the radius of the propeller ***R*** is 10 m. (a) Calculate the the maximum height attained by the object relative to the ground. (b) Calculate the time of flight. (c) Calculate the speed of impact at the point P. Take $g=9.80$ m/s^2



Hint: The angular speed, $\boldsymbol{\omega_0}$, and the initial speed, v_0, of the object are related by $v_0=\boldsymbol{\omega_0} R$.

a) $v_0 = R\omega_0 = 10 \times \frac{\pi}{4} = 7{,}85$ m/s

At the max height $v_y = 0 = v_{0y} - gt$

$t = \frac{v_{0y}}{g} = \frac{\pi/4 \times 10 \times \sin 45}{9{,}81} = 0{,}57$ s (2)

$h_{max} = (20 - 10 \times \sin 45) + \frac{\pi}{4} \times 10 \times \sin 45 \times 0{,}57 - \frac{1}{2} 9{,}81 \times 0{,}57^2$ (2)

$= 14{,}5$ m (1)

b) Solve $0 = (20 - 10 \cdot \sin 45) + \frac{\pi}{4} 10 \times \sin 45\, t_f - \frac{1}{2} 9{,}81\, t_f^2$ (4)

$\Rightarrow t_f = 2{,}29$ s (1)

c) $v_x = \frac{\pi}{4} \times 10 \times \cos 45 = 5{,}55$ m/s (2)

$v_y = v_{0y} - g t_f = \frac{\pi}{4} \times 10 \times \sin 45 - 9{,}81 \times 2{,}29 = -16{,}9$ m/s (2)

$\Rightarrow v = \sqrt{v_x^2 + v_y^2} = 17{,}8$ m/s (1)