YTU Physics Department 2023-2024 Fall Semester		Exam Date: 20.11.2023	Exam Duration: 110 min.
FIZ1001 PHYSICS-1 Midterm 1		The 9th article of Student Disciplinary Regulations of YÖK Law No.2547 states ***"Cheating or helping to cheat or*** *attempt to cheat in exams"* de facto perpetrators take **one or two semesters suspension** penalty.	
Question Sheet	**A A A A A**		
Name Surname		Students are **NOT** permitted to bring **calculators, mobile phones, smart watches** and/or any other unauthorized electronic devices into the exam room.	
Student No			
Physics Group No			
Department			
Exam Hall		**Student Signature:**	
Instructor's Name Surname			

$g = 10\ (m/s^2)$

$\vec{\bar{v}} = \frac{\Delta\vec{r}}{\Delta t}$; $\vec{\bar{a}} = \frac{\Delta\vec{v}}{\Delta t}$; $\vec{v} = \frac{d\vec{r}}{dt}$; $\vec{a} = \frac{d\vec{v}}{dt}$; $\vec{v} = \vec{v}_0 + \vec{a}t$; $\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$; $v^2 = v_0^2 + 2\vec{a}\cdot(\vec{r} - \vec{r}_0)$

$F_r = m\frac{v^2}{r}$; $F_s = -kx$; $f_s \le \mu_s N$; $f_k = \mu_k N$; $P = \vec{F}\cdot\vec{v}$; $W = \Delta K$; $W = \int \vec{F}\cdot d\vec{r}$; $\bar{P} = \frac{\Delta W}{\Delta t}$; $W = -\Delta U$

1) The force F is given in terms of time t and displacement x by the equation, $F = A\cos(Bx) + C\sin(Dt)$. Find the dimension of D/B.

$B \to [L^{-1}]$ $D \to [T^{-1}]$

A) $[L^{-1}\,T^{-1}]$ **B)** $[L^2\,T^{-1}]$ **C)** $[L\,T^{-1}]$ **D)** $[T^{-2}]$ **E)** $[L^{-1}\,T^{-2}]$

2) Vectors $\vec{A}$ and $\vec{B}$ are given by $\vec{A} = 2\hat{\imath} - \hat{\jmath} + 3\hat{k}$ and $\vec{B} = \hat{\imath} - 2\hat{\jmath} - 2\hat{k}$. Find the unit vector of $(\vec{A} \times \vec{B})$.

$\vec{A} \times \vec{B} = -4\hat{k} + 4\hat{j} + \hat{k} + 2\hat{i} + 3\hat{j} + 6\hat{i} = 8\hat{i} + 7\hat{j} - 3\hat{k}$

$\hat{u} = \frac{\vec{A}\times\vec{B}}{|\vec{A}\times\vec{B}|} = \frac{8\hat{i} + 7\hat{j} - 3\hat{k}}{\sqrt{122}}$

A) $\frac{8\hat{\imath} - \hat{\jmath} - 5\hat{k}}{\sqrt{90}}$ **B)** $\frac{4\hat{\imath} - 7\hat{\jmath} + 3\hat{k}}{\sqrt{74}}$ **C)** $\frac{8\hat{\imath} - 7\hat{\jmath} + \hat{k}}{\sqrt{114}}$ **D)** $\frac{8\hat{\imath} + 7\hat{\jmath} - 3\hat{k}}{\sqrt{122}}$ **E)** $\frac{8\hat{\imath} - 7\hat{\jmath} + 3\hat{k}}{\sqrt{122}}$

3) At $t = 0$ a body is started from origin with some initial velocity. The displacement x (m) of the body varies with time t (s) as $x = -\frac{2}{3}t^2 + 16t + 2$. How long does the body take to come to rest?

$a = \frac{d^2x}{dt^2} = -\frac{4}{3}\ m/s^2 \to$ constant

$v_f = v_i + at$ / $v(t) = -\frac{4}{3}t + 16$ $t = 0 \Rightarrow v_i = 16$

$0 = 16 - \frac{4}{3}t$

$t = 12\,s$

A) 12 (s) **B)** 13 (s) **C)** 14 (s) **D)** 15 (s) **E)** 16 (s)

4) For motion of an object along x-axis, the velocity v depends on the displacement x as ; $v = 5x^2 - 2x$. What is the acceleration at $x = 1$ (m).

$a = \frac{dv}{dt}\frac{dx}{dx} = \frac{dv}{dx}\frac{dx}{dt} = (10x - 2)(5x^2 - 2x) = 50x^3 - 20x^2 - 10x^2 + 4x$

$t = 1 \Rightarrow a = 50 - 20 - 10 + 4 = 24\ m/s^2$

A) 26 (m/s²) **B)** 16 (m/s²) **C)** 24 (m/s²) **D)** 18 (m/s²) **E)** 20 (m/s²)

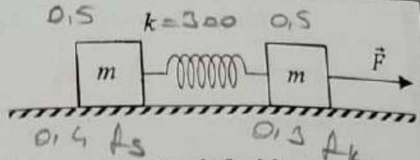
5) The trajectory equation of a projectile motion is given by; $y = \sqrt{3}\,x - \frac{1}{20}x^2$. If the horizontal component of the initial velocity of the object at $t = 0$ is 10 (m/s), find the flight time of the object in seconds.

$y = \sqrt{3}\,x - \frac{1}{20}x^2 \Rightarrow x_{1,2} = \frac{-\sqrt{3} \mp \sqrt{3+0}}{-\frac{2}{10}} \Rightarrow \begin{matrix} x_1 = 0 \\ x_2 = 20\sqrt{3}\ m \end{matrix}$

$\overset{20\sqrt{3}}{x_f} = \overset{0}{x_i} + \overset{10}{v_{ix}}t + \frac{1}{2}\overset{0}{a_x}t^2 \Rightarrow t = \underline{2\sqrt{3}\,s}$

A) $\sqrt{3}$ **B)** $2\sqrt{3}$ **C)** 2 **D)** 3 **E)** $3\sqrt{2}$

Questions 6-7 Two masses of $m = 0.5$ (kg) connected to each other by a spring with constant $k = 300$ (N/m) rest on a horizontal surface with friction coefficients $\mu_s = 0.4$ and $\mu_k = 0.3$. The spring is not extended. Once the mass attracted by the force F is put into motion, it moves at a constant speed.



6) What is the value of the horizontal force F in terms of Newton before the mass on the left side moves?

$v = constant \Rightarrow a = 0$

$F - f_k - f_s = 0 \quad \Rightarrow F = 1,5 + 2 = 3,5 N$

$0,3 \cdot 0,5 \cdot 10 \qquad 0,4 \cdot 0,5 \cdot 10$

A) 3.5 **B)** 3.0 **C)** 4.0 **D)** 4.5 **E)** 5.0

7) In this case, how many meters is the spring extended?

$F - f_k = k\Delta x \Rightarrow 3,5 - 1,5 = 300 \cdot \Delta x \Rightarrow \Delta x = 2/300$ m

A) $\frac{1}{300}$ **B)** $\frac{1}{200}$ **C)** $\frac{1}{350}$ **D)** $\frac{2}{300}$ **E)** $\frac{1}{400}$

8) A man wants to cross the river by boat that has a constant sped. If he crosses the river in minimum time, it takes 1 minutes with a 12 meters drift. If the man takes the shortest route to cross the river, it takes 2 minutes. Find the magnitude of the velocity of boat relative to the water in m/s.

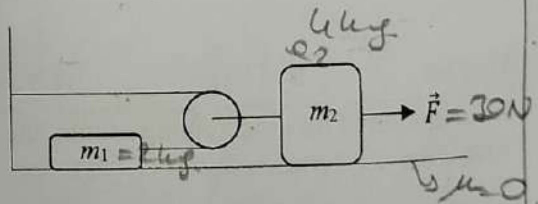
shortest time $v_b \uparrow \nearrow v_{b/r}$, $\to v_r$ $\quad v_r = 12/1 = 12$ m/min $\quad d = 1 v_b$

shortest route $v_b \nwarrow \uparrow v_{b/r}$, $\to v_r$ $\quad v_{b,r} = (v_b^2 - v_r^2) \Rightarrow t = 2 = \frac{1 v_b}{(v_b^2 - v_r^2)^{1/2}}$

$v_b^2 = \frac{4}{3} v_r^2 \Rightarrow v_b = \frac{2}{\sqrt{3}} \frac{12}{60}$ m/s

A) $\frac{2}{3\sqrt{3}}$ **B)** $\frac{3}{5\sqrt{3}}$ **C)** $\frac{2}{5}$ **D)** $\frac{3}{5}$ **E)** $\frac{2}{5\sqrt{3}}$

9) $F = 30$ (N) force is applied horizontally to the $m_2 = 4$ (kg) block on a frictionless surface. Find the acceleration of a mass of $m_1 = 2$ (kg) in m/s^2.



$a_1 = 2a_2$

$F - 2T = m_2 a_2 \Rightarrow 30 - 8a_2 = 4a_2$

$T = m_1 a_1 \qquad a_2 = 2,5 m/s^2$

$2 \quad 2a_2 \qquad a_1 = 5 m/s^2$

A) 7 **B)** 2 **C)** 5 **D)** 2.5 **E)** 8

10) The velocity components of a particle moving in the *xy*-plane are given by $v_x = 11 + 2t$ (m/s) and $v_y = 5$ (m/s). The particle is at the origin at $t = 0$. Find the radial acceleration of the particle in $t = 1$ second in unit of (m/s^2)?

$a_x = \frac{dv_x}{dt} = 2 m/s^2 \quad a_y = 0 \quad a_{total} = (a_x^2 + a_y^2)^{1/2} = 2$

$a_t = \frac{dv}{dt} = \frac{d((11+2t)^2 + 5^2)^{1/2}}{dt} =$

$a_{total} = (a_t^2 + a_r^2)^{1/2}$

$a_t = \frac{1}{2}((11+2t)^2 + 5^2)^{-1/2} \cdot 2(11+2t) \cdot 2$

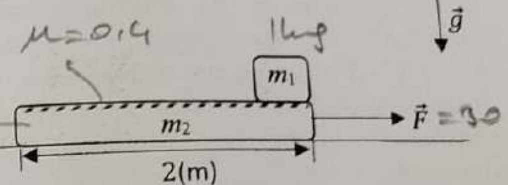
$2 \qquad \frac{26}{\sqrt{194}} \Rightarrow a_r = \frac{10}{\sqrt{194}}$

$a_t = 1s \Rightarrow a_t = 24/\sqrt{194}$

A) $\frac{36}{\sqrt{194}}$ **B)** $\frac{6}{\sqrt{184}}$ **C)** $\frac{20}{\sqrt{184}}$ **D)** $\frac{52}{\sqrt{146}}$ **E)** $\frac{10}{\sqrt{194}}$

Questions 11-12-13 A block with the mass $m_1 = 1$ (kg) is placed at the right end of a plank with the mass $m_2 = 2$ (kg). The length of the plank is 2 (m). Coefficient of friction between the block and the plank is 0.4 and the ground over which the plank is place is smooth. A constant force $F = 30$ (N) is applied on the plank in horizontal direction.

11) Find the acceleration of the plank relative to the block.



m_1g $\quad n_1 \quad m_2g$

$n_1 = 10$

$f = \mu n = 4N \qquad a_2 = \frac{30-4}{2} = 13\ m/s^2$

$a_1 = \frac{4}{1} = 4\ m/s^2 \qquad a_{21} = a_2 - a_1 = 13 - 4 = 9\ m/s^2$

A) 6 (m/s²) B) 9 (m/s²) C) 7 (m/s²) D) 8 (m/s²) E) 5 (m/s²)

12) Find the time when the block will separate from the plank.

$x_f = x_i + v_{ix}t + \frac{1}{2}at^2 \rightarrow ?$ $\qquad t = \sqrt{\frac{4}{9}}\ s$

A) 2 (s) B) $\frac{2}{\sqrt{6}}$ (s) C) $\frac{1}{\sqrt{2}}$ (s) D) $\frac{2}{\sqrt{5}}$ (s) E) $\frac{2}{3}$ (s)

13) What is the maximum magnitude of the force $\vec{F}$ that must be applied to keep the mass m_1 motionless relative to m_2?

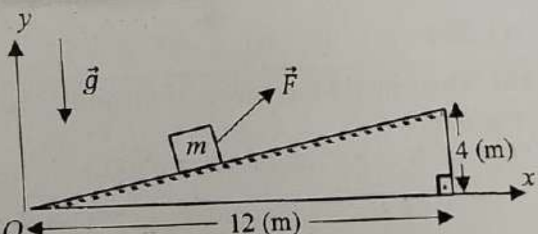
$F - f_s = m_2 a \Rightarrow F = 12N$ $\qquad a_1 = a_2 = a$

$f_s = \mu m_1 g = m_1 a \Rightarrow a = \mu g = 4\ m/s^2$

A) 12 (N) B) 10 (N) C) 8 (N) D) 6 (N) E) 15 (N)

Questions 14-15 As shown in the figure, a block with the mass $m = 1\ (kg)$ is pulled upwards on the inclined plane by the variable force $\vec{F}(x) = 4\hat{\imath} + x\hat{\jmath}$ (N) where x is in meters.

14) Until the block reaches to point (6,2) from point (0,0) what is the work done by the force $\vec{F}$?



$W = \int \vec{F} \cdot d\vec{r} = \int_0^6 4\,dx + \int_0^2 x\,dy = 4x\Big|_0^6 + \frac{3y^2}{2}\Big|_0^2$

$= 30$ joule

A) 25.5 (J) B) 30 (J) C) 27.5 (J) D) 26 (J) E) 32 (J)

15) When the block reaches point (6,2), the change in its kinetic energy is 5 (J), What is constant friction force in Newtons?

$W_F - W_G - W_{f_k} = \Delta K = 5$

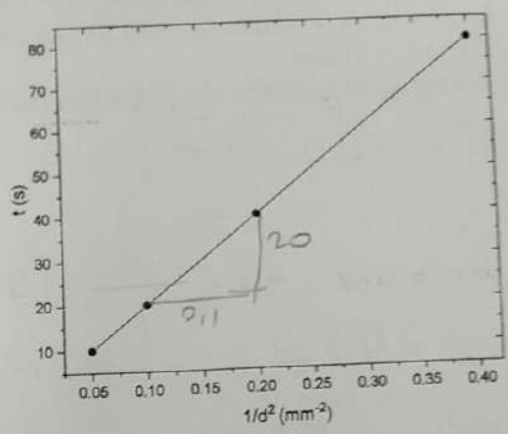
$30 - 20 - f_k \cdot \sqrt{40} = 5$

$mg\sin\theta \cdot \sqrt{40}$

$f_k = \frac{5}{\sqrt{40}} = \frac{5}{2\sqrt{10}}$ N

A) $\frac{5}{2\sqrt{10}}$ B) $\frac{5}{10\sqrt{40}}$ C) $\frac{5}{4\sqrt{10}}$ D) $\frac{5}{2\sqrt{40}}$ E) $\frac{5}{\sqrt{10}}$

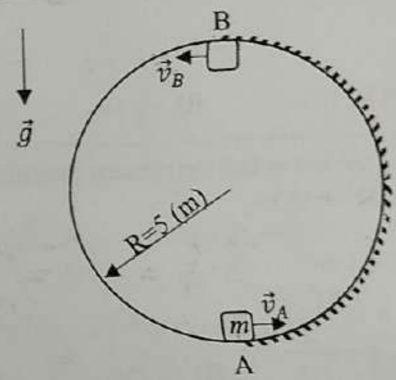
16) LABORATORY QUESTION: There is equal amount of water in four identical cylindrical containers. As a result of the experiment carried out to find the relationship between the water discharge times and hole diameters by drilling a hole of different diameters at the bottom of each container, $t = f\,(1/d^2)$ graph was drawn. Here t is time and d is the hole diameter. According to this graph, find the dependence of the water discharge time on the hole diameter.



$t = \tan\alpha \, \frac{1}{d^2} = \frac{200}{d^2}$

A) $t = \frac{160}{d^2}$ **B)** $t = \frac{170}{d^2}$ **C)** $t = \frac{180}{d^2}$ **D)** $t = \frac{190}{d^2}$ **E)** $t = \frac{200}{d^2}$

Questions 17-18-19 An object with mass $m = 2$ (kg) moves in a vertical plane on the rail system with radius 5 (m) as shown in the figure. The object passes through point A with the velocity $\vec{v}_A$.



17) If the work done by friction force between A and B is -100 (J), how many Joules is the change in the kinetic energy of the object between points A and B?

$W = \Delta K$

$W_g + W_{fk} = \Delta K = -300$ joule

$-\Delta U \quad -100$

$-mg2R$

A) 200 **B)** -300 **C)** -200 **D)** -400 **E)** 300

18) What should the speed of the object be while passing through point A so that the speed at point B is the minimum?

$n_B = 0 \Rightarrow v_B \Rightarrow min$

$n + mg = \frac{mv^2}{r} \Rightarrow v^2_{Bmin} = 50$

$W = \Delta K$

$-300 = \frac{1}{2} m (v_B^2 - v_A^2) \Rightarrow v_B = \sqrt{350}$ m/s

A) $\sqrt{300}$ (m/s) **B)** $\sqrt{200}$ (m/s) **C)** $\sqrt{150}$ (m/s) **D)** $\sqrt{350}$ (m/s) **E)** $\sqrt{250}$ (m/s)

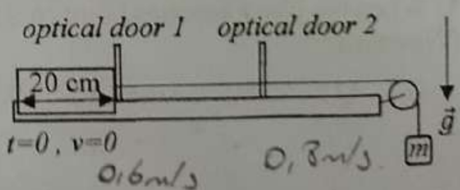
19) If the speed of the object passing through point B is $v_B = \sqrt{60}$ (m/s), find the reaction force applied to the object at point B.

$mg + n = m\frac{v^2}{r}$ $(v^2 \to 60,\ r \to 5)$ $\Rightarrow n = 4N$

$2 \quad 10 \quad ? \quad 2$

A) 12 (N) **B)** 10 (N) **C)** 44 (N) **D)** 4 (N) **E)** 24 (N)

20) LABORATORY QUESTION: In the Newton's laws experiment with air rail, as shown in the figure, the 20 (cm) long car starts moving from rest and leaves the first optical door with a speed of $v = 0.6$ (m/s). If the car enters to the second optical door at a speed of 0.8 (m/s), in how many seconds will it pass the second door?



$v_f^2 = v_i^2 + 2a\Delta x \Rightarrow a = 0,9\ m/s^2$ / $v_f^2 = v_i^2 + 2a\Delta x \Rightarrow v_f = 1\ m/s$

$0,6 \quad 0 \quad ? \quad 0,2$; $? \quad 0,8 \quad 0,9 \quad 0,2$

$v_f = v_i + a t$?

$1 \quad 0,8 \quad 0,9$

A) $\frac{1}{3}$ **B)** $\frac{1}{4}$ **C)** $\frac{2}{9}$ **D)** $\frac{2}{3}$ **E)** $\frac{2}{5}$

$t = 2/9\ s$