YTU Physics Department 2023-2024 Fall Semester		Exam Date: 10.01.2024 | Exam Duration: 110 dk.
FIZ1001 PHYSICS-1 FINAL		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. Students are **NOT** permitted to bring **calculators, mobile phones, smart watches** and/or any other unauthorized electronic devices into the exam room.
Question Sheet	**B B B B B**	
Name Surname		
Student No		
Physics Group No		
Department		
Exam Hall		
Instructor's Name Surname		**Student Signature:**

$\vec{\bar{v}}=\frac{\Delta\vec{r}}{\Delta t}$; $\vec{\bar{a}}=\frac{\Delta\vec{v}}{\Delta t}$; $\vec{v}=\frac{d\vec{r}}{dt}$; $\vec{a}=\frac{d\vec{v}}{dt}$; $\vec{v}=\vec{v}_0+\vec{a}t$; $\vec{r}=\vec{r}_0+\vec{v}_0t+\frac{1}{2}\vec{a}t^2$; $v^2=v_0^2+2\vec{a}\cdot(\vec{r}-\vec{r}_0)$; $F_r=m\frac{v^2}{r}$; $F_s=-kx$

$f_s\le\mu_sN$; $f_k=\mu_kN$; $P=\vec{F}\cdot\vec{v}$; $W_{total}=\Delta K$; $W=\int\vec{F}\cdot d\vec{r}$; $\bar{P}=\frac{\Delta W}{\Delta t}$; $\vec{F}_{conservative}=-\frac{dU}{dr}\hat{r}$; $W_{conservative}=-\Delta U$

$W=\Delta U+\Delta K$; $U=mgy$; $U=\frac{1}{2}kx^2$; $\vec{F}=\frac{d\vec{p}}{dt}$; $\vec{p}=m\vec{v}$; $\vec{I}=\Delta\vec{p}=\vec{\bar{F}}\Delta t$; $\vec{r}_{cm}=\frac{\sum m_i\vec{r}_i}{\sum m_i}$; $\vec{r}_{cm}=\frac{\int\vec{r}dm}{\int dm}$; $\vec{\bar{\omega}}=\frac{\Delta\vec{\theta}}{\Delta t}$; $\vec{\bar{\alpha}}=\frac{\Delta\vec{\omega}}{\Delta t}$

$\vec{\omega}=\frac{d\vec{\theta}}{dt}$; $\vec{\alpha}=\frac{d\vec{\omega}}{dt}$; $\vec{\omega}=\vec{\omega}_0+\vec{\alpha}t$; $\vec{\theta}=\vec{\theta}_0+\vec{\omega}_0t+\frac{1}{2}\vec{\alpha}t^2$; $\omega^2=\omega_0^2+2\alpha(\theta-\theta_0)$; $a_t=r\alpha$; $\vec{\tau}=\vec{r}\times\vec{F}$; $\vec{\tau}_0=I_0\vec{\alpha}$

$K_{rot}=\frac{1}{2}I\omega^2$; $I=\int r^2dm$; $I=I_{cm}+MD^2$; $P=\vec{\tau}\cdot\vec{\omega}$; $W=\int\vec{\tau}\cdot d\vec{\theta}$; $\vec{L}=\vec{r}\times\vec{p}$; $\vec{L}=I\vec{\omega}$; $\vec{\tau}=\frac{d\vec{L}}{dt}$; $\vec{\bar{\tau}}=\frac{\Delta\vec{L}}{\Delta t}$

$v_{cm}=R\omega$; $x(t)=A\cos(\omega t+\varphi)$; $T=\frac{1}{f}$; $\omega=2\pi f$; $E=\frac{1}{2}kA^2$ $\qquad g=10\ (\mathrm{m/s^2})$

Question 1) An object of mass M at rest is divided into three equal parts due to internal forces. Immediately after the explosion, the first piece has a velocity of $\vec{v}_1=400\hat{\imath}+300\hat{\jmath}$ (m/s), the second piece has a velocity of $\vec{v}_2=350\hat{\imath}-200\hat{\jmath}$ (m/s). Find the velocity vector of the third part.

$P_1=0=\frac{M}{3}(400\hat{i}+300\hat{j})+\frac{M}{3}(350\hat{i}-200\hat{j})+\frac{M}{3}(\vec{v}_3)\Rightarrow$ $v_3=-750\hat{i}-100\hat{j}$ m/s.

A) $750\hat{\imath}-500\hat{\jmath}$ B) $-450\hat{\imath}-100\hat{\jmath}$ C) $150\hat{\imath}-200\hat{\jmath}$ D) $-750\hat{\imath}-100\hat{\jmath}$ E) $-150\hat{\imath}-100\hat{\jmath}$

Questions 2-3) A particle of mass 0.2 kg has a position vector $\vec{r}=20t\hat{\imath}+(15t-5t^2)\hat{\jmath}$. When $t=2$ seconds.

2) Find the angular momentum with respect to the point $\vec{r}_0=60\hat{\imath}$.

$\vec{R}=\vec{r}-\vec{r}_0=40\hat{i}+(30-20\hat{j})-60\hat{i}=-20\hat{i}+10\hat{j}$

$\vec{P}=m\vec{v}=0,2.[(15-10t)\hat{j}+20\hat{i})]=0,2(20\hat{i}-5\hat{j})$

$\vec{L}=\vec{r}\times\vec{P}=(-20\hat{i}+10\hat{j})\times0,2(20\hat{i}-5\hat{j})=-20\hat{k}$

A) $-60\hat{k}$ (J.s) B) $60\hat{k}$ (J.s) C) $-20\hat{k}$ (J.s) D) $30\hat{k}$ (J.s) E) $80\hat{k}$ (J.s)

3) Find the torque with respect to the point $\vec{r}_0=60\hat{\imath}$.

$\vec{\tau}=\vec{r}\times\vec{F}=(-20\hat{i}+10\hat{j})\times0,2(-10\hat{j})=40\hat{k}$ N.

A) $-30\hat{k}$ (N) B) $30\hat{k}$ (N) C) $-40\hat{k}$ (N) D) $50\hat{k}$ (N) E) $40\hat{k}$ (N)

Question 4-5) A particle moves along the x axis. Its position is given by the equation $x=2+2t-4t^2$, with x in meters and t in seconds.

4) Determine its position when it changes direction.

$\frac{dx}{dt}=0$ ($v=0$) $\Rightarrow$ it changes its direction

$v=2-8t=0\Rightarrow t=1/4$ s.

$x=2+2\frac{1}{4}-4\frac{1}{4}\frac{1}{4}=\frac{9}{4}$ m

A) $\frac{3}{4}$ (m) B) $\frac{9}{4}$ (m) C) $\frac{5}{4}$ (m) D) $\frac{7}{2}$ (m) E) $\frac{7}{4}$ (m)

5) Determine its velocity when it returns to the position it had at $t=0$.

$t=0\Rightarrow x=2$m.

$2=2+2t-4t^2\Rightarrow t=0,5$s.

$v=2-8.0,5=-2$m/s.

A) -3 (m/s) B) -0.5 (m/s) C) -1 (m/s) D) -2 (m/s) E) -0.25 (m/s)

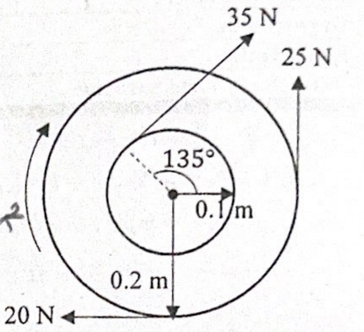
Question 6) A conservative force, $\vec{F} = (6x - 12)\hat{\imath}$ where x is in meters, acts on a particle moving along an x axis. The potential energy U associated with this force is assigned a value of 27 (J) at $x = 0$. Write an expression for U as a function of x, with U in joules and x in meters.

$F = -\frac{dU}{dx} \Rightarrow \int_{U_0}^{U} dU = \int_0^x -F\,dx = -3x^2 + 12x \Big|_0^x \Big\}\ U - 27 = -3x^2 + 12x$

$\quad F \hookrightarrow 6x - 12$

A) $27 + 12x - 3x^2$ B) $27 - 12x - 3x^2$ C) $27 + 12x + 3x^2$ D) $-27 + 12x - 3x^2$ E) $-27 - 12x - 3x^2$

Question 7) Under the influence of the forces in the figure, a constant friction torque of 0.5 (N.m) acts on the wheel rotating clockwise with an angular acceleration of 10 $(\frac{\text{rad}}{\text{s}^2})$. Find the moment of inertia of the wheel.



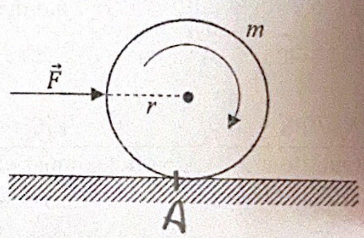
$\tau = I\alpha$

$35 . 0{,}1 - 25 . 0{,}2 + 20 . 0{,}2 - 0{,}5 = I . 10$

$3{,}5 - 5 + 4 - 0{,}5 = 10\,I \Rightarrow I = 0{,}2\ \text{kgm}^2$

A) 0.5 (kg.m^2) B) 1.3 (kg.m^2) C) 0.2 (kg.m^2) D) 1.1 (kg.m^2) E) 0.3 (kg.m^2)

Questions 8-9) Consider a uniform disc of mass m, radius r, rolling without slipping on a rough surface with linear acceleration a and angular acceleration α due to an external force $\vec{F}$ as shown in the figure Moment of inertia of disk about center of mass; $I = \frac{1}{2}mr^2$.



8) Find the magnitude of frictional force acting on the disc?

$\tau = I\alpha \Rightarrow FR = \left(\frac{1}{2}mR^2 + mR^2\right)\alpha$

$\quad \alpha \hookrightarrow a/R$

$F = \frac{3}{2}ma$

$F - f_s = ma \Rightarrow f_s = F - \underbrace{ma}_{2F/3} = \frac{F}{3}$

A) $\frac{3F}{5}$ B) $\frac{F}{3}$ C) $\frac{2F}{3}$ D) $\frac{F}{2}$ E) $\frac{F}{4}$

9) What is the angular velocity of the disk after it rotates through an angle of 15 radians from rest?

$\omega_f^2 = \underbrace{\omega_i^2}_{0} + 2\alpha\Delta\theta = \frac{20F}{mR}$

$\Delta\theta \to 15$

$\alpha \hookrightarrow a/R \hookrightarrow \frac{2F}{3m}$

A) $\omega = \sqrt{\frac{10F}{mr}}$ B) $\omega = \sqrt{\frac{30F}{mr}}$ C) $\omega = \sqrt{\frac{60F}{mr}}$ D) $\omega = \sqrt{\frac{15F}{mr}}$ E) $\omega = \sqrt{\frac{20F}{mr}}$

Question 10) The angular position of a point on the rim of a rotating wheel is given by $\theta = 4t - 3t^2 + t^3$, where θ is in radians and t is in seconds. What is the average angular acceleration for the time interval that begins at $t = 2$ (s) and ends at $t = 4$ (s).

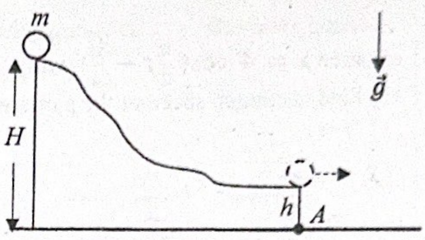
$\bar{\alpha} = \frac{\Delta\omega}{\Delta t} = \frac{\omega(4) - \omega(2)}{2} = \frac{28 - 4}{2} = 12\ \text{rad/s}^2.$

$\omega = \frac{d\theta}{dt} = 4 - 6t + 3t^2 \Rightarrow \omega(4) = 28\ \text{rad/s}$

$\omega(2) = 4\ \text{rad/s}.$

A) 12 (rads^{-2}) B) 1.5 (rads^{-2}) C) 6 (rad s^{-2}) D) 4 (rads^{-2}) E) 8 (rads^{-2})

11) In figure, a solid ball rolls smoothly from rest, starting at height $H = 9$ (m) until it leaves the horizontal section at the end of the track, at height $h = 2$ (m). Since the ball leaves the surface with a horizontal velocity how far horizontally from point A does the ball hit the floor? Moment of inertia, $I = \frac{2}{5}mr^2$ and $g = 10 m/s^2$.



$U_i = K_{tf} + K_{Rf}$ $\quad v/r$

$mg(H-h) = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

10 9 2 $\quad \frac{2}{5}mr^2$

$y_f = y_i + v_{iy}t - \frac{1}{2}10t^2 \Rightarrow t^2 = 0.4 s.$

0 2 0

$v = 10 m/s.$

$x_f = x_i + v_{ix}t \Rightarrow x_f = 2\sqrt{10}$

? 0 10 $\sqrt{0.4}$

A) $5\sqrt{10}$ (m) B) $\sqrt{20}$ (m) C) $2\sqrt{10}$ (m) D) $2\sqrt{20}$ (m) E) $7\sqrt{10}$ (m)

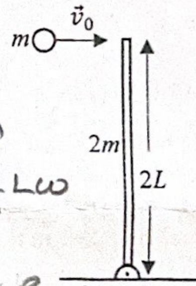
Question 12) At $t = 0$ a 1(kg) ball is thrown from a tall tower with velocity, $\vec{v} = (18\hat{i} + 24\hat{j})$ (m/s). While the ball continues to fall freely, find the potential energy change of the ball between $t = 0$ and $t = 6$ (s). Take $g = 10 m/s^2$.

$\Delta U = mg\Delta h$ $\quad \Delta h = v_{0y}t - \frac{1}{2}gt^2 = 144 - 180 = -36$ m.

1 10 -36 $\quad$ 24 6 10 6

A) −360 (J) B) −720 (J) C) 360 (J) D) 720 (J) E) 3240 (J)

Questions 13-14) A plank of length $2L$ and mass $2m$ is hinged at its lower end, lies on a frictionless table. A ball of mass m and velocity $\vec{v}_0$ strikes its end as shown and its turns back along the same line with velocity $\vec{v}_f$.



Moment of inertia of plank of length l and mass m, $I = \frac{1}{12}ml^2$.

13) Find the final velocity of the ball v_f assuming that mechanical energy is conserved. ①

$L_i = L_f \Rightarrow m v_0 2L = m v_f 2L + \frac{1}{3}2m(2L)^2\omega \Rightarrow v_0 - v_f = \frac{4}{3}L\omega$

$E_i = E_f \Rightarrow \frac{1}{2}mv_0^2 = \frac{1}{2}mv_f^2 + \frac{1}{2}\left(\frac{1}{3}2m(2L)^2\right)\omega^2$

$\Rightarrow v_0^2 - v_f^2 = \frac{8}{3}L^2\omega^2$

$\underbrace{(v_0 - v_f)}_{\frac{4}{3}L\omega}(v_0 + v_f) = \frac{8}{3}L^2\omega^2 \Rightarrow v_0 + v_f = 2L\omega$ ②

use ① and ② $v_f = v_0/5$ (it should be (−) since it is turning back)

A) $-\frac{2v_0}{3}$ B) $-\frac{v_0}{3}$ C) $-\frac{2v_0}{5}$ D) $-\frac{v_0}{5}$ E) $-\frac{3v_0}{5}$

14) Find the angular velocity of the plank after the colision.

$v_0 - v_f = \frac{4}{3}L\omega \Rightarrow \omega = 3v_0/5L$

$v_f \to \frac{v_0}{5}$

A) $\frac{v_0}{5L}$ B) $\frac{2v_0}{5L}$ C) $\frac{2v_0}{3L}$ D) $\frac{v_0}{2L}$ E) $\frac{3v_0}{5L}$

Question 15) A 140 (kg) hoop rolls along a horizontal floor so that the hoop's center of mass has a speed of 0.20 (m/s). How much work must be done on the hoop to stop it? Inertia of the hoop, $I = mr^2$.

$W = \Delta K = K_f - K_i$

0 $\quad \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ $\quad mr^2$ $\quad v/r$

$\Rightarrow W = -mv^2 = -5.6$ joule.

140 0.2

A) −2.8 (J) B) −5.6 (J) C) 5.6 (J) D) −28 (J) E) 2.8 (J)

Question 16-17-18) A mass spring system is in simple harmonic motion in one dimension and moves according to the equation $x = 4\ \cos(\frac{\pi}{2}t - \frac{\pi}{4})$, with x in meters and t in seconds. Take $\pi = 3$.

16) Find maximum speed of the particle?

$v = \frac{dx}{dt} = -4\underbrace{\frac{\pi}{2}}_{v_{max}}\sin(\frac{\pi}{2}t - \frac{\pi}{4})$ $\Big\}$ $v_{max} = 2\pi = 6\ m/s$.

A) 4 (m/s) **B)** 1 (m/s) **C)** 3 (m/s) **D)** 6 (m/s) **E)** 2 (m/s)

17) At what value of x is the potential energy of the particle equal to half the total energy?

$E_{Total} = 2U$

$\hookrightarrow \frac{1}{2}kA^2$, $A \hookrightarrow 4$; $U \hookrightarrow \frac{1}{2}kx^2$

$\Rightarrow x^2 = 8 \Rightarrow x = 2\sqrt{2}\ m$.

A) $3\sqrt{2}$ (m) **B)** $\sqrt{2}$ (m) **C)** $4\sqrt{2}$ (m) **D)** 2 (m) **E)** $2\sqrt{2}$ (m)

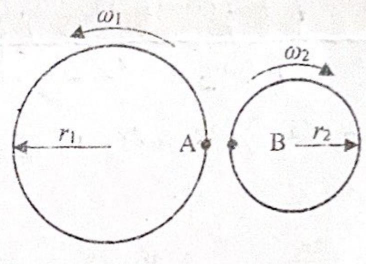
18) How long does the particle take to move to this position x from the equilibrium position?

$x = 4\cos(\frac{\pi}{2}t - \frac{\pi}{4})$, $x \hookrightarrow 2\sqrt{2}$ $\Rightarrow \frac{\sqrt{2}}{2} = \cos\underbrace{(\frac{\pi}{2}t - \frac{\pi}{4})}_{\theta} \Rightarrow \theta = \frac{\pi}{4} = \frac{\pi}{2}t - \frac{\pi}{4}$

$t = 1\ s$

A) 0.75 (s) **B)** 0.5 (s) **C)** 1 (s) **D)** 2(s) **E)** 1.25 (s)

Question 19) As shown in the figure, points A and B are marked on the circles rotating independently. Here $\omega_1 = 3$ (rad/s), $r_1 = 4$ (m) and $\omega_2 = 4$ (rad/s), $r_2 = 2$ (m). After how many seconds will points A and B appear in the same position for the first time? Take $\pi = 3$.



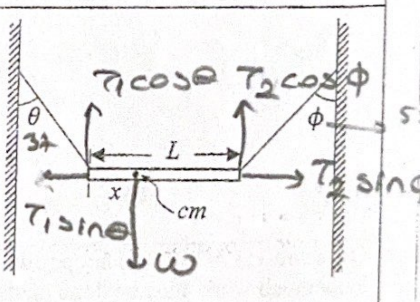
$v_1 = \omega_1 r_1 = 12\ m/s$ $T_1 = \frac{2\pi r_1}{v_1} = 2\ s$

$v_2 = \omega_2 r_2 = 8\ m/s$ $T_2 = \frac{2\pi r_2}{v_2} = 1{,}5\ s$

The lowest common multiple of T_1 and $T_2 \Rightarrow 6\ s$

A) 6 **B)** 5 **C)** 4 **D)** 3 **E)** 2

Question 20) In figure a nonuniform bar is suspended at rest in a horizontal position by two massless cords. One cord makes the angle $\theta = 37^0$ with the vertical; the other makes the angle $\phi = 53^0$ with the vertical. If the length of the bar is $L = 10$ (m); Compute the distance x from the left end of the bar to its center of mass. ($cos37^0 = sin53^0 = 0.8$, $cos53^0 = sin37^0 = 0.6$)



$\Sigma_{leftside} = T_2\cos\phi L - Wx = 0 \Rightarrow x = \frac{T_2\cos\phi L}{W}$

$T_2\sin\phi - T_1\sin\theta = 0$

$T_1\cos\theta + T_2\cos\phi - W = 0 \Rightarrow \frac{T_2}{W} = 0{,}6$

$\downarrow \frac{T_2\sin\phi}{\sin\theta}$

$x = 0{,}6\ 0{,}6 \cdot 10 = 3{,}6\ m$

A) 2.6 (m) **B)** 3 (m) **C)** 3.6 (m) **D)** 3.2 (m) **E)** 2.8 (m)