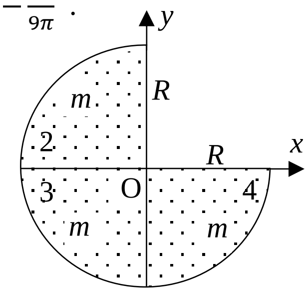
YTU Physics Department 2019-2020 Fall Semester		Exam Date: 07.12.2019	Exam Duration: 100 min.
FIZ1001 PHYSICS-1 Midterm Exam 2		The 9th article of Student Disciplinary Regulations of YÖK Law No.2547 states ***"Cheating or helping to cheat or attempt to cheat in exams"*** de facto perpetrators take **one 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	**A A A A A**		
Name Surname			
Student No			
Physics Group No			
Department			
Exam Hall		**Student Signature:**	
Instructor's Name Surname			

$\vec{F}_{conservative} = -\frac{dU}{dr}\hat{r}\,; W_{conservative} = -\Delta U\,; U = mgy\,; U = \frac{1}{2}kx^2\,; \vec{F} = \frac{d\vec{p}}{dt}\,; \vec{p} = m\vec{v}\,; \vec{I} = \Delta\vec{p} = \vec{F}\Delta t\,; f_s \le \mu_s N\,; f_k = \mu_k N$

$\overline{\vec{\omega}} = \frac{\Delta\vec{\theta}}{\Delta t}\,; \overline{\vec{\alpha}} = \frac{\Delta\vec{\omega}}{\Delta t}\,; \vec{\omega} = \frac{d\vec{\theta}}{dt}\,; \vec{\alpha} = \frac{d\vec{\omega}}{dt}\,; \vec{\omega} = \vec{\omega}_0 + \vec{\alpha}t\,; \vec{\theta} = \vec{\theta}_0 + \vec{\omega}_0 t + \frac{1}{2}\vec{\alpha}t^2\,; \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)\,; v = r\omega\,; a_t = r\alpha$

$F = -kx\,; \vec{r}_{cm} = \frac{\sum m_i\vec{r}_i}{\sum m_i}\,; \vec{r}_{cm} = \frac{\int \vec{r}dm}{\int dm}\,; \vec{\tau} = \vec{r}\times\vec{F}\,; \vec{\tau}_0 = I_0\vec{\alpha}\,; I = \int r^2 dm\,; P = \vec{\tau}\cdot\vec{\omega}\,; W = \int\vec{\tau}\cdot d\vec{\theta}\,; \bar{P} = \frac{\Delta W}{\Delta t}\,; W = \Delta U + \Delta K$

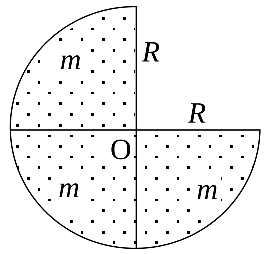
Questions 1-2 The coordinates of center of mass of disk ¾ in the figure are $x_{cm} = y_{cm} = -\frac{4R}{9\pi}$.
Each quarter slice is identical and has a mass of m.



1) Find the coordinates of center of mass x_{2cm}, y_{2cm} of the 2nd quarter respectively

A) $-\frac{R}{3\pi}, \frac{4R}{3\pi}$ **B)** $-\frac{4R}{3\pi}, \frac{4R}{3\pi}$ **C)** $-\frac{4R}{\pi}, \frac{2R}{\pi}$ **D)** $-\frac{2R}{3\pi}, \frac{2R}{3\pi}$ **E)** $-\frac{R}{\pi}, \frac{R}{\pi}$

2) If the moment of inertia perpendicular to the surface of a disk with radius R and mass M and relative to the axis passing through the center of mass is $I_{cm} = \frac{1}{2}MR^2$; Find the moment of inertia with respect to the axis passing through the point O and perpendicular to the plane of disk ¾ in the figure.



A) $\frac{3}{4}mR^2$ **B)** $\frac{1}{12}mR^2$ **C)** $\frac{1}{2}mR^2$ **D)** $\frac{3}{2}mR^2$ **E)** $\frac{1}{3}mR^2$

Questions 3-4 Only one conservative force acts on an object moving on the x-axis. The potential energy function of the object is given by $U(x)=3x^2+6x$ (J).

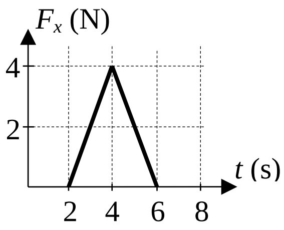
3) If the potential energy of the object is 24 (J), between which x values $[-x_{max}, +x_{max}]$ does the object move?

A) [-2, 2] (m) **B)** [2, 4] (m) **C)** [-4, 0] (m) **D)** [0, 2] (m) **E)** [-4 , 2] (m)

4) If the mass of the object is m = 2 (kg), what is the magnitude (m/s²) of the acceleration when the object passes through x = 0?

A) 3 **B)** 4 **C)** 2 **D)** 5 **E)** 1

Questions 5-6 An object with a mass of 4 (kg) is accelerated on the *x*-axis. The time-dependent graph of the applied net force is as shown in the figure.



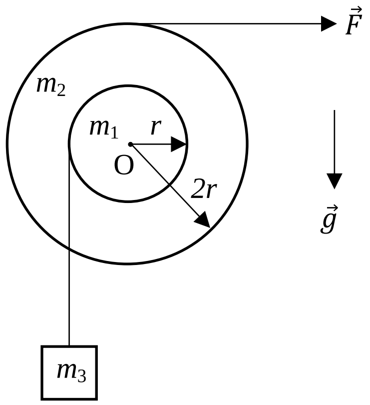
5) What is the change in velocity of the object between t = 2 (s) and t = 6 (s) in (m/s)?

A) 3 **B)** 4 **C)** 2 **D)** 5 **E)** 1

6) What is the average force that acts on the object between t = 2 (s) and t = 6 (s) in (N)?

A) 3 **B)** 4 **C)** 2 **D)** 5 **E)** 1

Questions 7-8-9 Two pulleys with masses m_1 = 1 (kg) and m_2 = 2 (kg) fixed coaxially to each other are fixed on the wall so that they can rotate around point O. Mass m_3 = 3 (kg) is connected to the rope wound on a reel with radius r = 1 (m). Initially a constant force of $F = 20$ (N) is applied on the system at rest as shown in the figure. Assuming there is enough rope on the reels;



7) How many seconds does it take for the reels to make one cycle?

(π =3 ; g = 10 m/s^2) (*The moment of inertia of a pulley with radius r and mass m that is relative to the axis passing through the center of mass is* $I_{cm} = \frac{1}{2}mr^2$.)

A) $\sqrt{2}$ **B)** $\frac{1}{3}$ **C)** 3 **D)** 2 **E)** $\frac{1}{2}$

8) At the end of this time, what is the angular velocity of the reels in (rad/s)?

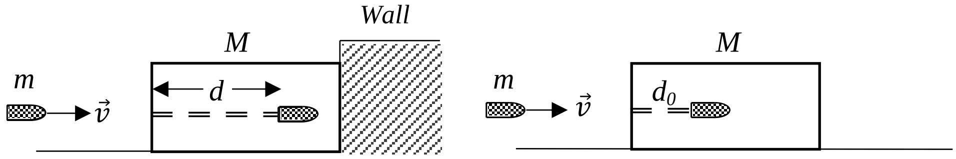
A) $\frac{3}{2}$ **B)** $\frac{1}{2}$ **C)** 3 **D)** 4 **E)** $\frac{1}{\sqrt{2}}$

9) How many Watts does the net torque consume in one cycle?

A) 120 **B)** 140 **C)** 48 **D)** 12 **E)** 24

Questions 10-11 A plastic block with mass M rests against the wall on the <u>frictionless</u> floor as shown in figure (a). A bullet with a mass of m is fired towards the block at a velocity of $\vec{v}$ and the bullet travels a distance of d in the block until it stops. Assuming that a constant frictional force f acts on the bullet within the block;

10) Find the friction force f.



(a) (b)

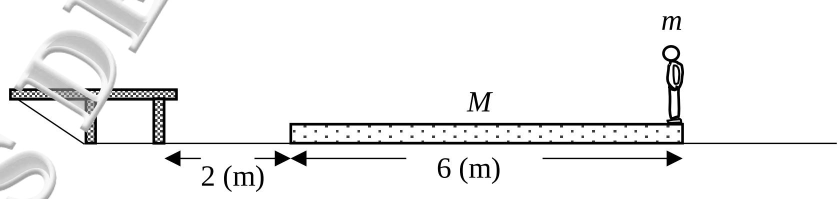
A) $\frac{2mv^2}{5d}$ **B)** $\frac{mv^2}{2d}$ **C)** $\frac{2mv^2}{3d}$ **D)** $\frac{4mv^2}{3d}$ **E)** $\frac{mv^2}{d}$

11) Calculate the (d_0) path taken by the bullet when the same bullet is fired at the velocity $\vec{v}$ in the same plastic block on the <u>frictionless</u> surface as shown in figure (b).

A) $\frac{Md}{m+M}$ **B)** $\frac{2Md}{m+M}$ **C)** $\frac{Md}{2m+M}$ **D)** $\frac{Md}{m+2M}$ **E)** $\frac{3Md}{m+M}$

Questions 12-13-14 A person with a mass of m = 60 (kg) stands at the right end of a water-floating raft with a length of L = 6 (m) and a mass of M = 140 (kg). Initially, the raft is at rest amd 2 (m) far away from the pier. Assume that there is no friction between the raft and the water. The man starts running at a constant speed of v = 4 (m/s) <u>relative to the raft</u>. *(The raft has uniform density)*

12) Find the velocity of the raft in (m/s).



A) 2 **B)** 1.2 **C)** 1.5 **D)** 6 **E)** 0.5

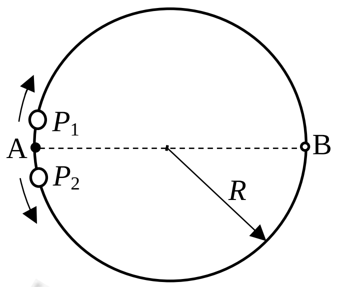
13) <u>How many meters does the raft move far away from the pier</u>, when the man was passing through middle of the raft?

A) $\frac{4}{3}$ **B)** $\frac{11}{3}$ **C)** $\frac{7}{2}$ **D)** $\frac{29}{10}$ **E)** $\frac{9}{4}$

14) From this moment on, the man slides and starts to slow down and stands at the end of the raft. Find the magnitude of the impulse in (N.s) acting on the raft in the time interval when the man reaches the end of the raft from the middle of the raft.

A) 168 **B)** 560 **C)** 280 **D)** 336 **E)** 256

Questions 15-16-17-18 As shown in the figure, the point objects P_1 and P_2 start circular motion in the opposite direction from point A at rest position. P_1 moves with constant linear acceleration, P_2 moves with constant angular velocity ω_0.



15) What should the linear acceleration of P_1 be so that the objects can meet at point B?

A) $\frac{R\omega_0{}^2}{4\pi}$ **B)** $\frac{R\omega_0{}^2}{2\pi}$ **C)** $\frac{2R\omega_0{}^2}{3\pi}$ **D)** $\frac{R\omega_0{}^2}{\pi}$ **E)** $\frac{2R\omega_0{}^2}{\pi}$

16) Find the angular velocity of P_1 at point B.

A) $\omega_0\pi$ **B)** $\frac{\omega_0}{\pi}$ **C)** $2\omega_0$ **D)** $\frac{\omega_0}{2}$ **E)** $2\pi\omega_0$

17) If point B started to rotate <u>clockwise</u> at the same time with a constant angular velocity ω_0, what would the angular acceleration of P_1 be so that the objects could meet at point B?

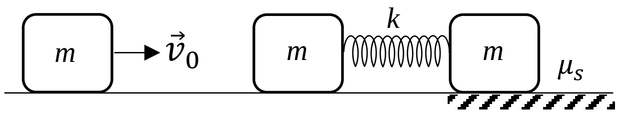
A) $\frac{8\omega_0{}^2}{\pi}$ **B)** $\frac{12\omega_0{}^2}{\pi}$ **C)** $24\omega_0{}^2$ **D)** $\frac{26\omega_0{}^2}{\pi}$ **E)** $\frac{48\omega_0{}^2}{7\pi}$

18) In this situation, what is the angular velocity of point P_1 at point B?

A) $\frac{\omega_0}{4}$ **B)** $\frac{3\omega_0}{2}$ **C)** $2\omega_0$ **D)** $6\omega_0$ **E)** ω_0

Questions 19-20 Two blocks of mass m are connected to a spring with a spring constant k. The rightmost block is in the <u>friction</u> section as shown in the figure and the static friction coefficient between the block and the ground is μ_s. Another block with a mass m is hitting the other block to the right with a velocity $\vec{v}_0$.

19) What should the maximum compression be in the spring so that the rightmost block does not move?

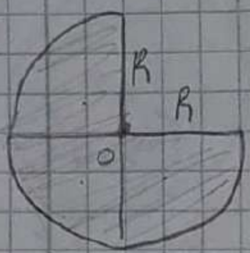


A) $\frac{3\mu_s mg}{2k}$ **B)** $\frac{2\mu_s mg}{3k}$ **C)** $\frac{\mu_s mg}{4k}$ **D)** $\frac{2\mu_s mg}{k}$ **E)** $\frac{\mu_s mg}{k}$

20) What should the maximum value of v_0 be so that the rightmost block does not move?

A) $\mu_s g\sqrt{\frac{2m}{k}}$ **B)** $\mu_s g\sqrt{\frac{m}{2k}}$ **C)** $2\mu_s g\sqrt{\frac{3m}{k}}$ **D)** $\mu_s g\sqrt{\frac{3m}{2k}}$ **E)** $2\mu_s g\sqrt{\frac{m}{k}}$

2019 mid 2



$$X_{cm} = Y_{cm} = \frac{-4R}{9\pi}$$

1) X_{2cm}, Y_{2cm} of 2nd quarter = ?

$$X_{cm} = \frac{\sum_{i=1}^{3} m_i x_i}{\sum_{i=1}^{3} m_i} = \frac{m \cdot x_1 + m(-x_2) + m(-x_3)}{3m}$$

$$= \frac{-\cancel{m}X}{3\cancel{m}} = -\frac{X}{3} = \frac{-4R}{9\pi}$$

$$\Rightarrow \frac{4R}{3\pi}$$

the distance between X_{cm} and origin.

let m be the mass of one quarter

since all quarters are the same, their $|X_{cm}|$ are the same

Because the disk is symmetric, $X_{cm} = Y_{cm}$

since 2nd quarter is left-up $\Rightarrow CM = \left(-\frac{4R}{3\pi}, \frac{4R}{3\pi}\right)$

2)

hard ☹

mass dencity

- only one conservative force acts on an object

$U(x) = 3x^2 + 6x$

3) if the potential energy is 24 $[-x_{max}, x_{max}] = ?$

$U = 3x^2 + 6x = 24$ → $(x-2)(x+4) = 0$

$3x^2 + 6x - 24 = 0$ $\underline{\underline{x=2}}$ $x = \underline{-4}$

$x^2 + 2x - 8 = 0$

4) at $x=0$ $a = ?$ $(m=2)$

$W = \int F\,dx = -U$ $\boxed{F = ma}$

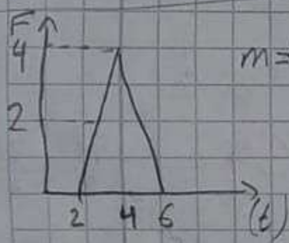
$\int ma\,dx = -3x^2 - 6x$

$\left(\frac{d}{dx}\right)$

$ma = -6x - 6 \Rightarrow a = -3x - 3 \Rightarrow a = -3$

$(m=2)$ $(x=0)$

$|a| = 3$



$m=4$

5) whats the change in velocity between 2 and 6 ?

$I = \Delta P$ — Impulse = Area of the triangle

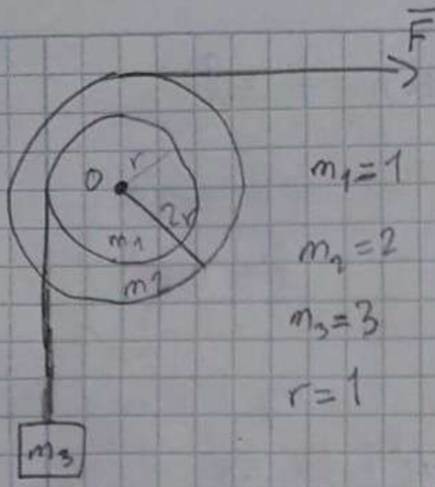
$8 = mV_f - mV_i$ $= 4 \cdot 2 = 8$

$4V_f - 4V_i = 8 \Rightarrow V_f - V_i = 2$

6) $\bar{F} = ?$

$I = \bar{F} \cdot t$

$8 = \bar{F} \cdot 4 \Rightarrow \bar{F} = 2$



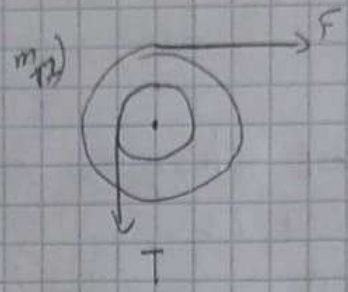
$m_1 = 1$

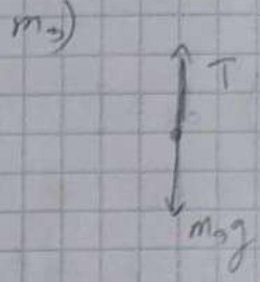
$m_2 = 2$

$m_3 = 3$

$r = 1$

7) how many seconds does it take for the reels to make one cycle?





$$\boxed{\Sigma F = ma}$$

for m_3) $T - m_3 g = m_3 a$

$T - 30 = 3a$

$T = 3a + 30$ ①

$I^{sys} = I^{m_1} + I^{m_2} = \frac{1}{2} m_1 r^2 + \frac{1}{2} m_2 4 r^2$

$= \frac{1}{2} + 4 = 9/2$

for reels) $\Sigma \tau = I^{sys} \alpha$

$F \cdot 2r - T \cdot r = I^{sys} \alpha$

$\alpha = \frac{a}{r}$

$\Rightarrow \alpha = a$

$40 - T = \frac{9}{2} a$

$40 - 3a - 30 = \frac{9}{2} a$

$10 = \frac{9}{2} a + 3a$

$10 = \frac{15}{2} a \Rightarrow a = \frac{4}{3}$

$\Rightarrow \alpha = \frac{4}{3}$

$\Delta \theta = \cancel{\omega_i t} + \frac{1}{2} \alpha t^2$

$2\pi = \frac{1}{2} \cdot \frac{4}{3} t^2 \Rightarrow t^2 = 9 \Rightarrow t = 3$

8) $\omega_f = ?$ $\quad \omega_f = \cancel{\omega_i} + \alpha t$

$\omega_f = \frac{4}{3} \cdot 3 = 4$

9) Power $= ? = \tau \cdot \omega = 6 \cdot 4 = 24$

$\Sigma \tau = F \cdot 2 - T = 40 - 34$

$T = 3a + 30 \qquad = 6$

$= 3 \cdot \frac{4}{3} + 30$

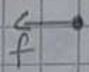
$= 34$

frictionless floor

friction is constant

10) friction $f = ?$

bullet)



$$\Sigma F = ma$$

$$f = m a$$

$a = ?$

by kinematic equations

$$\cancel{v_f^2} = V_i^2 + 2a\,\Delta x$$

$$0 = V_i^2 + 2a\,d$$

$$\Rightarrow a = -\frac{V^2}{2d}$$

$$f = ma = -\frac{mV_i^2}{2d}$$

11) $d_o = ?$ The first thing to come to my mind is conservation of momentum. Idk if it's correct or not, yet.

$$P_i = P_f$$

$$mV = (m+M)\,V_f$$

$$\Rightarrow V_f = \frac{mV}{(m+M)}$$

What now? I actually tried kinematic equations, but I don't have neither acc nor time. Then, I thought of conservation of energy. However I realized that Work - K.E theory is easier.

$$\Sigma W = K_f - K_i$$

$$\underbrace{\vec{f}\cdot\vec{d_o}}_{\text{only friction made work}} = \underbrace{\frac{1}{2}(m+M)\,V_f^2}_{\text{the bullet and block are moving}} - \frac{1}{2}mV^2$$

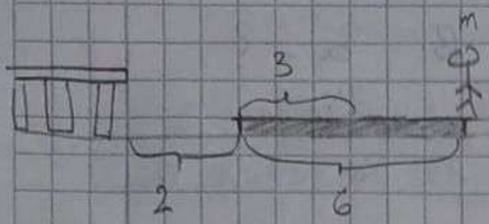
$$-f\cdot d_o = \frac{1}{2}\cancel{(m+M)}\frac{m^2V^2}{(m+M)^{\cancel{2}}} - \frac{1}{2}mV^2$$

$$-\frac{\cancel{mV^2}}{\cancel{2}d}\,d_o = \frac{\cancel{1}}{\cancel{2}}\frac{m^{\cancel{2}}\cancel{V^2}}{(m+M)} - \frac{\cancel{1}}{\cancel{2}}\cancel{m}\cancel{V^2}$$

$$-\frac{d_o}{d} = \frac{m}{(m+M)} - 1$$

$$\frac{-d_o}{d} = \frac{\cancel{m} - \cancel{m} - M}{m+M} \Rightarrow d_o = \frac{dM}{m+M}$$

$m = 60$ $\quad l = 6$ $\quad V = 4$ (m/s) reletive to raft.
$M = 140$



12) find the velocity of the raft?

$$\underbrace{V_{pg}}_{\text{Person to ground}} = \overbrace{V_{pr}}^{\text{Person to raft}} + \underbrace{V_{rg}}_{\text{raft to ground}}$$

$V_{pg} = 4 + V_{rg}$

$P_i = P_f$

$$0 = 60\underbrace{(4 + V_{rg})}_{\text{Person to ground}} + 140\, V_{rg} \Rightarrow 0 = 240 + 60\, V_{rg} + 140\, V_{rg}$$

$-240 = 200\, V_{rg}$

$\underline{V_{rg} = -1{,}2}$

negative ≡ opposite direction

13) whe the man is on the middle, how many meters does the raft moves?

CM position doesn't change

$$CM_i = \frac{m x_1 + M x_2}{m + M} = \frac{\cancel{8}^{4} \cdot 60 + 5 \cdot \cancel{140}^{70}}{\cancel{200}_{100}} = \frac{240 + 350}{100} = 5{,}9$$

when the man is on the middle of the boat, his and the boat's position are on the CM. So the boat have moved from 5 to 5,9 ⇒ 0,9 m

14) The man slides - - - - impulse $I = ?$

$J = \Delta P = P_f - \cancel{P_i}^{0} = 140 \cdot V_{f\,raft}$

for man

$V_f^2 = \underbrace{V_i^2}_{V_{pr}} + 2ad$

$0 = 4^2 + 2\, a_{man} \cdot 3$

$\Rightarrow a_{man} = -\dfrac{8}{3}$

$V_f = V_i + at$

$0 = 4 - \dfrac{8}{3} t$

$\Rightarrow t = \dfrac{3}{2}$ s

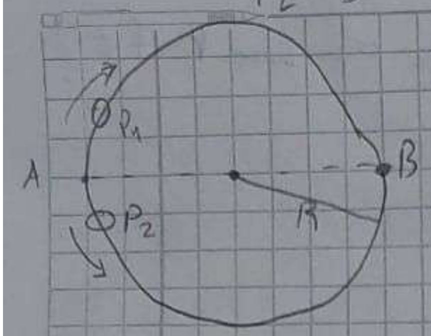
$\dfrac{9}{10} = \dfrac{1}{2}\, a_{raft}\, t^2$

$\dfrac{9}{10} = \dfrac{1}{2}\, a_{raft} \cdot \dfrac{9}{4} \Rightarrow a_{raft} = 0{,}8$

$V_{raft,f} = a_{raft} \cdot t = 0{,}8 \cdot \dfrac{3}{2} = 1{,}2$

$J = 140 \cdot 1{,}2 = 168$

P_1 has constant linear acc: a
P_2 " " angular velocity: ω_0



15) if P_1 meets P_2 at B $a = ?$

$\Delta\theta = \omega_0 t$ ← the time that P_2 needs to reach B

$\pi = \omega_0 t$

$\Rightarrow \boxed{t = \frac{\pi}{\omega_0}}$

$\Delta\theta = \cancel{\omega_i}^{0}\, t + \frac{1}{2}\alpha t^2$ ← the time that P_1 needs to reach B

$\alpha = \frac{a}{R}$

$\pi = \frac{1}{2} \frac{a}{R} \frac{\pi^2}{\omega_0^2}$

$\Rightarrow a = \frac{2R\omega_0^2}{\pi}$

$\alpha = \frac{a}{R} = \frac{2\omega_0^2}{\pi}$

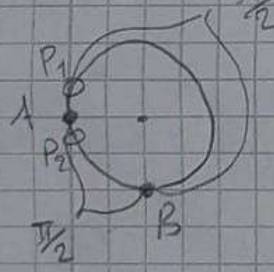
16) at B P_1's $\omega = ?$

$\omega_f = \cancel{\omega_i}^{0} + \alpha t$

$\omega_f = \frac{2\omega_0^2}{\pi} \cdot \frac{\pi}{\omega_0} = 2\omega_0$

17) if B starts rotating clock wise with ω_0 - - - -
firstly P_2 will meet point B at the bottom of the circle. Why? because both started moving on oppsite points and they approach each other with the same speed.

same steps as question 15



$\Delta\theta = \omega_0 t$

$\frac{\pi}{2} = \omega_0 t \Rightarrow t = \frac{\pi}{2\omega_0}$

$\Delta\theta = \cancel{\omega_i}^{0}\, t + \frac{1}{2} \alpha t^2$

$\frac{3\pi}{2} = \frac{1}{2} \alpha \frac{\pi^2}{4\omega_0^2} \Rightarrow \alpha = \frac{12\omega_0^2}{\pi}$

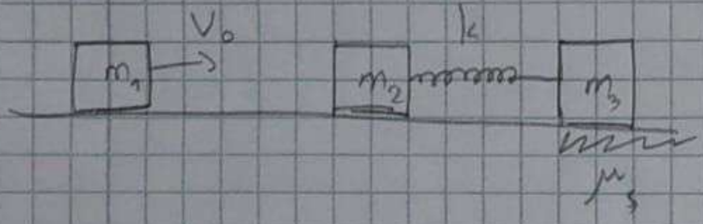
18) ω of P_1 = ?

$\omega_f = \cancel{\omega_i}^{0} + \alpha t$

$\omega_f = \frac{12\omega_0^2}{\pi} \cdot \frac{\pi}{2\omega_0} = 6\omega_0$

{future me: I accedentally solved both 19 and 20 in 19's solution}

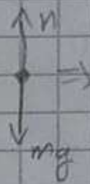
19) what's the max x (x_{max})



max static friction

$= f_{s\,max} = n \cdot \mu_s$

$= \boxed{mg\,\mu_s}$



$\Rightarrow n = mg$

Firstly, m_1 will collid with m_2

$\Rightarrow$ Conservation of Momentum

$$P_i = P_f$$

$$m\,V_0 = (m+m)\,V_f$$

$$\Rightarrow V_f = \frac{V_0}{2}$$

Then, the two blocks will squish the spring untill they reach x_{max} where they stop.

Conservation of Energy

$$E_i = E_f$$

$$K_i + \cancel{U_i} = \cancel{K_f}^{0} + U_f$$

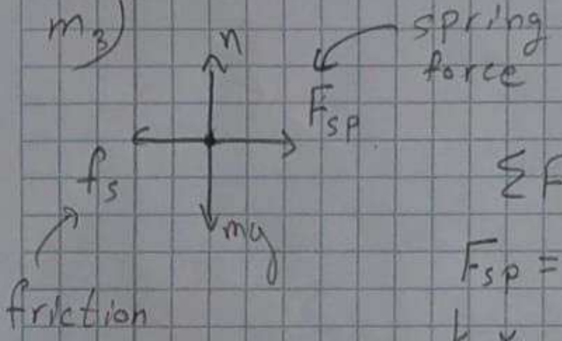
$$\frac{1}{2}\cdot 2m\left(\frac{V_0}{2}\right)^2 = \frac{1}{2}k\,x_{max}^2$$

$$m\,\frac{V_0^2}{4} = \frac{1}{2}k\,x_{max}^2$$

$$x_{max}^2 = \frac{m\,V_0^2}{2k}$$

finally, the spring will apply force on m_3 but m_3 will not move because of friction

m_3)



$\Sigma F = 0$ ← no move

$$F_{sp} = f_{s\,max}$$

$$k\,x_{max} = mg\,\mu_s \Rightarrow x_{max} = \frac{mg\,\mu_s}{k}$$

20) what should be the max V_0

$$x_{max}^2 = \frac{m\,V_0^2}{2k} \Rightarrow V_0 = \sqrt{\frac{2k}{m}}\,x_{max} = \sqrt{\frac{2k}{m}}\cdot\frac{mg\,\mu_s}{k}$$

$$= \sqrt{\frac{2k\cdot m^2}{m\cdot k^2}}\,g\,\mu_s$$

$$= g\,\mu_s\cdot\sqrt{\frac{2m}{k}}$$