İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy101 Physics I
Final Examination
July 01, 2025 10:20 – 11:50
Good Luck!

NAME-SURNAME:

SIGNATURE:

◇ **I declare hereby that I fulfilled the requirements for the attendance according to the University regulations and I accept that my examination will not be valid otherwise.**

ID:

DEPARTMENT:

INSTRUCTOR:

DURATION: 90 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		10
2		20
3		20
4		15
5		20
TOTAL		100

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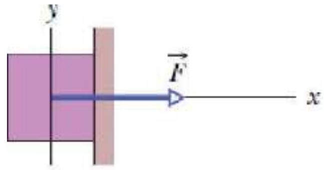
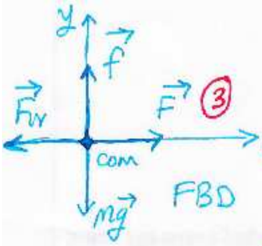
1. A) A 12 N horizontal force pushes a block weighing 5.0 N against a vertical wall (see Figure).The coefficient of static friction between the wall and the block is 0.60, and the coefficient of kinetic friction is 0.40. Assume that the block is not moving initially.



i Will the block move? Why?

ii In unit-vector notation, what is the force on the block from the wall?



Newton's 2nd law.

① $x: F - F_N = m a_x$ ②

② $y: f - mg = m a_y$ ②

③ $f = \mu F_N$ ②

if no motion $\rightsquigarrow a_x = a_y = 0$

i) if $f \leq \mu_s F_N$ no motion

if $f > \mu_s F_N$ block slides

① $\rightarrow F - F_N = 0 \sim F_N = 12N$

$f_s: \mu_s F_N = 0.6 * 12N = \boxed{7.2N}$

② $\rightsquigarrow f - mg = 0 \rightsquigarrow f = \boxed{5N}$ ③

$\Rightarrow 5N < 7.2N$ $\boxed{\text{no motion}}$

ii) since no motion ③

$\vec{F}_{bw} = -F_N \hat{i} + f \hat{j} = \boxed{-12N \hat{i} + 5N \hat{j}}$

B) A force acts on a particle and it is given as function of position, $F = a/x^2$, where $a = 9.0\ Nm^2$. Calculate the change in the potential energy going from the point $x = 1.0\ m$ to $x = 3.0\ m$.

$$F\Delta x = W$$
$$F\Delta x = -\Delta U$$
$$F = -\frac{\Delta U}{\Delta x}$$

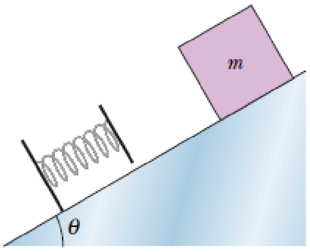
$$F \sim F(x) = a/x^2$$
$$U = \int \Delta U = -\int F\,dx$$

5

$$U = -\int_1^3 9/x^2\,dx$$
$$= \frac{9}{x}\Big|_1^3 = (3-9) = \boxed{-6 \text{ Joule}}$$

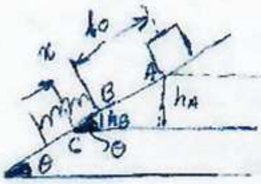
3 2

2. A block of mass $m = 2\ kg$ is released from rest on a frictionless incline of angle $\theta = 30°$ as given in the figure. Below the block is a spring that can be compressed $2.0\ cm$ by a force of $270\ N$. The block **momentarily stops** when it compresses the spring by $5.5\ cm$.



i How far does the block move down the incline from **its rest position to this stopping point** ?

ii What is the **speed** of the block **just as it touches the spring**?



$\mathcal{U} = mgh_A$

$\mathcal{U} = 0$ at point C

$\sin\theta = \dfrac{h_A}{x + l_o}$ 2

$\vec{F} = -k\vec{x}$

$270N = k\ 2\times10^{-2} m$

$\Rightarrow k = 13500\ N/m = 1.35\times10^{4}\ N/m$

$m = 2\ kg$

i) $x = 5.5\times10^{-2} m$ (Point C)

$K_f + \mathcal{U}_f = K_i + \mathcal{U}_i$ 3

$0 + (\mathcal{U}_g + \mathcal{U}_s)_f = 0 + (\mathcal{U}_g)_i$

$0 + (0 + \frac{1}{2}kx^2) = 0 + mgh_A$ 2

$\frac{1}{2}(1.35\times10^{4} N/m)(5.5\times10^{-2} m)^2 = (2kg)(9.8 m/s^2)\, h_A$ 2

$h_A = \dfrac{20.4\ Nm}{19.6\ N} = 1.04\ m = (\sin 30)(x + l_o)$

$\rightarrow l_o = \dfrac{1.04m}{\sin 30} - x = 2.08 - 5.5\times10^{-2}$

$= 2.03m$ 2

$\boxed{l_o + x = 2.08 m}$ 1

ii) Point B; $\Delta h = h_A - h_B$

$K_f + \mathcal{U}_f = K_i + \mathcal{U}_i$ 2

$\frac{1}{2} m v_B^2 + mg h_B = 0 + mgh_A$ 2

$\frac{1}{2} v_B^2 = g(h_A - h_B)$ $\left|\begin{array}{l} h_A = (x + l_o)\sin 30° \\ h_B = x \sin 30 \end{array}\right\}$ $h_A - h_B = l_o \sin 30°$ 2

$v_B^2 = 2g\, l_o \sin 30 = 2 * 9.8 m/s^2 (2.03m) \sin 30$

$\Rightarrow \boxed{v_B = 4.46\ m/s}$ 2

3. A soccer player kicks a soccer ball of mass 0.45 kg that is initially at rest. The foot of the player is in contact with the ball for 3.0×10^{-3} s, and the force of the kick is given by

$$F(t) = [(6.0 \times 10^{6})t - (2.0 \times 10^{9})t^{2}]\ N$$

for $0 \leq t \leq 3.0 \times 10^{-3}$ s, where t is in seconds. Find the magnitudes of

i the impulse on the ball due to the kick,

ii the average force on the ball from the player's foot during the period of contact,

iii the maximum force on the ball from the player's foot during the period of contact,

iv the ball's velocity immediately after it loses contact with the player's foot.

$m = 0.45$ kg
Initially at rest
Contact time $= 3.0 \times 10^{-3}$ s
$F(t) = [6.0 \times 10^{6} t - 2.0 \times 10^{9} t^{2}]\ N$
$0 \leq t \leq 3.0 \times 10^{-3}$ s

i) $J = ?$ impulse $\vec{F}_{av} = \frac{\vec{J}}{\Delta t}$ OR 2 $J = \int F(t)\,dt = \int_0^{3\times10^{-3}} (6\times10^{6} t - 2\times10^{9} t^{2})\,dt$

$\rightarrow J = 3\times10^{6} t^{2} - \frac{2\times10^{9}}{3} t^{3} \Big|_0^{3\times10^{-3}} = 3\times10^{6}(9\times10^{-6}) - \frac{2}{3}\times10^{9}(27\times10^{-9})$ $\boxed{= 9\ Ns}$ 2 1

ii) $F_{av} = \frac{J}{\Delta t} = \frac{9\,Ns}{3.0\times10^{-3}\,s}$ $\boxed{= 3\times10^{3}\ N}$ 2 2 1

iii) $F_{max} = ?$ during the period of contact

$\frac{dF(t)}{dt} = 0 \rightarrow 6\times10^{6} - 4\times10^{9} t = 0 \Rightarrow t = 1.5\times10^{-3}\ s$ 2

$\Rightarrow F(t = 1.5\times10^{-3}\ s) = F_{max} = 6\times10^{6}(1.5\times10^{-3}) - 2\times10^{9}(1.5\times10^{-3})^{2}$ 1

$\boxed{F_{max} = 4.5\times10^{3}\ N}$ 1 1

iv) $v = ?$ when contact is lost.

$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = m\vec{v}_f - m\vec{v}_i \rightarrow \Delta p = mv = J \Rightarrow v = \frac{J}{m} = \frac{9\,Ns}{0.45\,kg} = 20\ kg\frac{m}{s^2}\frac{s}{kg}$ 2

$\boxed{v = 20\ m/s}$ 2 1

4. A disk rotates about its central axis starting from rest and accelerates with constant angular acceleration. At one time it is rotating at 20 rev/s; 40 revolutions later, its angular speed becomes 30 rev/s.

   i Calculate the angular acceleration,

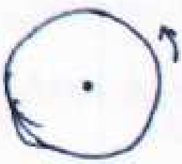
   ii Calculate the time required to complete the 40 revolutions,

   iii Calculate the time required to reach the 20 rev/s angular speed,

   iv Calculate the number of revolutions from rest until the time the disk reaches the 20 rev/s angular speed.

   v Consider a point on the disk at 10 cm from the center. Calculate the centripetal (radial) acceleration of this point when the disk rotates at 20 rev/s.

   vi Calculate the tangential linear acceleration of the above mentioned point.



starts from rest, $\omega_0 = 0$

α : constant

$\omega_i = 20\,rev/s \rightarrow \underbrace{40\,rev}_{\Delta\theta} \rightarrow \omega_f = 30\,rev/s$ 1

i) $\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$ 1

$\left(30\times 2\pi\,\frac{rad}{s}\right)^2 = \left(20\times 2\pi\,\frac{rad}{s}\right)^2 + 2\alpha\; 40\times 2\pi\,rad \Rightarrow \alpha = 39.27\,rad/s^2$

1 1 $\alpha = 6.25\,rev/s^2$

ii) $\omega_f = \omega_i + \alpha t$ 1

$30\,rev/s = 20\,rev/s + 6.25\,rev/s^2\,t \rightarrow t = 1.6\,s$ 1 1

iii) $\omega_f = \omega_0 + \alpha t$ 1

$20\,rev/s = 0 + 6.25\,rev/s^2\,t \rightarrow t = 3.2\,s$ 1

iv) $\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$ 1

$(20\,rev/s)^2 = 0 + 2\times 6.25\,rev/s^2\,\Delta\theta \rightarrow \Delta\theta = 32\,rev$ 1

1

v) $R = 10\,cm = 0.1\,m$, $a_r = \frac{v^2}{R} = \frac{(\omega R)^2}{R} = \omega^2 R = (20\,rev/s)^2\,0.1\,m$

$= 40\,m/s^2$ 1

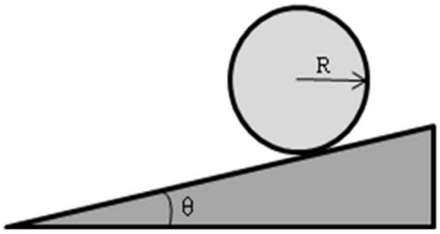
vi) $v = \omega R = (20\,rev/s)\,0.1\,m = 2\,m/s$

1 1

5. A uniform ball, of mass $M = 6.0$ kg and radius R, rolls smoothly from rest down a ramp at angle $\theta = 30.0°$ (see Figure, $I = \frac{2}{5}MR^2$)

i The ball descends a vertical height $h = 1.20$ m to reach the bottom of the ramp. What is its speed at the bottom?

ii What are the magnitude and direction of the frictional force (f_s) on the ball as it rolls down the ramp?



$M = 6\,kg$
$\theta = 30°$
$I_{com} = \frac{2}{5}MR^2$
$h = 1.2\,m$

i) Mechanical Energy is conserved for the ball-earth system

$\rightsquigarrow F_N$ & f_s does not work (5)

$$K_f + \cancel{U_f} = \cancel{K_i} + U_i \rightsquigarrow K_f = U_i \rightsquigarrow \frac{1}{2}I_{com}\omega^2 + \frac{1}{2}Mv_{com}^2 = Mgh$$

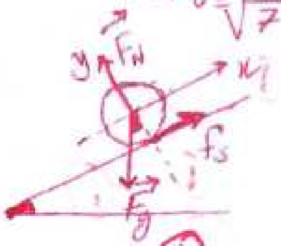
$$\rightsquigarrow \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v_{com}}{R}\right)^2 + \frac{1}{2}Mv_{com}^2 = Mgh$$

$$\frac{7}{10}\cancel{M}v_{com}^2 = \cancel{M}gh \rightsquigarrow v = \sqrt{\frac{10}{7}gh}$$

$$\rightsquigarrow v = \sqrt{\frac{10}{7}(9.8\,m/s^2)(1.2\,m)} = \underline{4.1\,m/s} \quad (1)$$

(2)

ii)



(4)

Newton's 2nd law in x-direction

$$-Mg\sin 30° + f_s = Ma_{com,x} \quad (2)$$

Newton's 2nd law in angular form

$$\tau_{net} = I_{com}\alpha \rightsquigarrow f_sR = \frac{2}{5}MR^2\alpha \quad (2)$$

$$a_{com,x} = -\alpha R \rightsquigarrow \frac{5}{2}f_s = -Ma_{com,x}$$

$$\Rightarrow -Mg\sin 30° + f_s = -\frac{5}{2}f_s \rightsquigarrow f_s = \frac{2}{7}Mg\sin 30° \quad (1)\ (1)$$

(2)

$$= \frac{2}{7}(6\,kg)(9.8\,m/s^2)\frac{1}{2} = \underline{8.4\,N}$$