İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy101 Physics I
Final Examination
January 07, 2026 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		15
2		20
3		15
4		15
5		20
TOTAL		100

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1. A) A 650 kg elevator starts from rest. It moves upward for 3.00 s with **constant acceleration** until it reaches the speed of 1.75 m/s.

   i What is the average power of the elevator motor during this time interval?

   ii What is the average power of the elevator motor during an upward trip with **constant speed**?

$P_{avg} = \vec{F} \cdot \vec{v}_{avg} \rightsquigarrow F ?\ v_{avg} ?$

i) FBD: $\uparrow F_{motor}$, $\downarrow F_g$ (2)

Newton's 2^{nd} law

$\vec{F}_{net} = m\vec{a}$

$y: F_{motor} - mg = ma$

(2) $F_{motor} = m(a+g)$

Constant acceleration

$v = v_0 + at \rightsquigarrow a = \dfrac{v - v_0}{t}$

$v_0 = \phi$, $v = 1.75 m/s$, $t = 3s$

$\rightsquigarrow a = \dfrac{1.75 m/s}{3s} = 0.583 m/s^2$ (1) (1)

$\rightarrow F_{motor} = 650kg(0.583 m/s^2 + 9.81 m/s^2) = \underline{6.76 \times 10^3 kg\,m/s^2}$

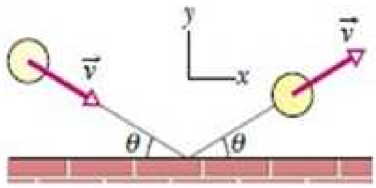
(2) $v_{avg} = \dfrac{v_i + v_f}{2} = \dfrac{\phi + 1.75 m/s}{2} = 0.875 m/s$ (1) (1)

$\Rightarrow P_{avg} = F_{motor} v_{avg} \cos\phi = 6.76 \times 10^3 N \cdot 0.875 m/s = \boxed{5.91 \times 10^3 W}$

ii) Constant speed $\rightsquigarrow a = \phi$ (1) $F_{motor} = mg$ & $v_{avg} = \dfrac{(1.75 + 1.75)}{2} = 1.75 m/s$ (2) (1)

$\Rightarrow P_{avg} = F_{motor} v_{avg} = mg\, v_{avg} = 650 kg\ 9.81 m/s^2\ 1.75 m/s = \boxed{1.11 \times 10^4 W}$ (1)

B) In figure, a 300 g ball with a speed v of 6.0 m/s strikes a wall at an angle θ of 30° and then rebounds with the *same speed and angle*. It is in contact with the wall for 10 ms.



In unit vector notation, what are

i the impulse on the ball from the wall,

ii the average force on the wall from the ball?

$\vec{v}_i = v\cos\theta\,\hat{i} - v\sin\theta\,\hat{j} = 5.2\,\hat{i} - 3.0\,\hat{j}$ (2)

rebounds with same speed & angle $|\vec{v}_i| = |\vec{v}_f|$

$\vec{v}_f = v\cos\theta\,\hat{i} + v\sin\theta\,\hat{j} = 5.2\,\hat{i} + 3.0\,\hat{j}$ (2)

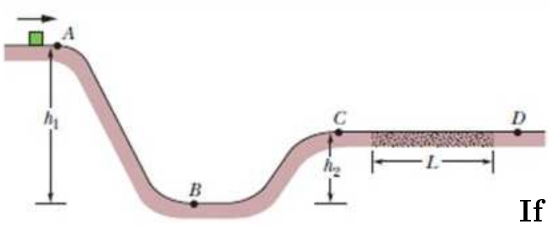
i) $\vec{J} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = 2(0.30\,kg)(3.0\,m/s)\hat{j}$ (2)

$= (1.8\ Ns)\hat{j}$ (1) upward (1)

ii) $\dfrac{\vec{J}}{\Delta t} = \vec{F} = \dfrac{1.8}{0.010}\hat{j} = (180\ N)\hat{j}$ (2) (1) (1) average force on the ball from the wall

Newton's third law: $(-180\ N)\hat{j}$ (3) : average force on the wall from the ball

2. In figure, a small block is sent through point A with a speed of $25.2\ km/h$. Its path is without friction until it reaches the section of length $L = 6\ m$, where the coefficient of kinetic friction is 0.70. The indicated heights are $h_1 = 6.0\ m$ and $h_2 = 2.0\ m$.



What are the speeds of the block at

i point B?

ii point C?

iii Does the block reach point D?

If so, what is its speed there; **if not**, how far through the section of friction does it travel?

$v_A = 25.2\ km/h$ ~ we need in m/s ~ chain product $25.2 \frac{km}{h} \frac{1000m}{km} \frac{1h}{3600s} = \underline{7 m/s}$ (2)

without friction : no $\Delta E_{th} \rightsquigarrow \Delta E_{mech} = \Delta K + \Delta U = 0$: Conservation of Mechanical Energy

$F_{ext} \cdot \Delta x = \cancel{W} = \Delta E_{mech} + \cancel{\Delta E_{th}} + \cancel{\Delta E_{int}} \rightsquigarrow K_f + U_f = K_i + U_i$

i) (2) $K_A + U_A = K_B + \cancel{U_B} \rightsquigarrow \frac{1}{2} m v_A^2 + mgh_1 = \frac{1}{2} m v_B^2 \rightsquigarrow v_B = \sqrt{v_A^2 + 2gh_1}$ (1)

$= \sqrt{(7 m/s)^2 + 2 \cdot 9.8 m/s^2\, 6m} = \boxed{12.9 m/s}$ (1) (1)

ii) from $A \to C$ $K_A + U_A = K_C + U_C$ (1)

(2) $\frac{1}{2} m v_A^2 + mgh_1 = \frac{1}{2} m v_C^2 + mgh_2$

$\rightsquigarrow v_C = \sqrt{v_A^2 + 2g(h_1 - h_2)} = \boxed{11.3 m/s}$ (1) (1)

from $B \rightsquigarrow C$ $K_B + \cancel{U_B} = K_C + U_C$

$\frac{1}{2} m v_B^2 = \frac{1}{2} m v_C^2 + mgh_2$

$\rightsquigarrow v_C = \sqrt{v_B^2 - 2gh_2} = \boxed{11.3 m/s}$

iii) with friction : $\Delta E_{th} = f_k d = \mu_k F_N d = (0.70) m (9.81 m/s^2)(6m) = (41.16 m) m^2/s^2$ (2)

$\Delta E_{mech} + \Delta E_{thermal} = 0$: Conservation of Energy : $\Delta K + \Delta U + \Delta E_{th} = 0$

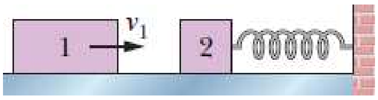
from $C \rightsquigarrow D$: $K_D - K_C + \underbrace{U_D - U_C}_{same} + \Delta E_{th} = 0 \rightsquigarrow \frac{1}{2} m (v_D^2 - v_C^2) + (41.16 m) m^2/s^2 = 0$ (2)

Does the block reach point D? Since $63.85 > 41.16$ $\boxed{YES}$ (2)

$\frac{1}{2} m v_C^2 = \frac{1}{2} m (11.3 m/s)^2 = (63.85 m) m^2/s^2 \rightsquigarrow \frac{1}{2} m v_D^2 - (63.85 m) m^2/s^2 + (41.16 m) m^2/s^2 = 0$

$\rightsquigarrow v_D = \sqrt{2 \times 22.69 m^2/s^2} = \boxed{6.74 m/s}$ (1) (1)

3. In figure below, block 2 (mass 1.0 kg) is at rest on a frictionless surface and touching the end of an unstretched spring of spring constant 200 N/m. The other end of the spring is fixed to a wall. Block 1 (mass 2.0 kg), traveling at speed $v_1 = 4.0\ m/s$, collides with block 2, and the two blocks **stick** together.



The blocks system momentarily stop, by what distance is the spring compressed?

$\vec{P}_i = \vec{P}_f$: Conservation of momentum $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

stick together : $v_{1f} = v_{2f} = v_c$ ⇝ 3 $m_1 v_1 = (m_1 + m_2) v_c$

& $v_{2i} = \phi$ & $v_{1i} = v_1$ ⇝ $v_c = \frac{m_1 v_1}{m_1 + m_2} = \frac{(2kg)(4m/s)}{(2kg + 1kg)} = \frac{8}{3} m/s = \boxed{2.67 m/s}$ 2 1 1

without friction ⇝ conservation of E_{mech} 2 ⇝ $\Delta K + \Delta U = 0$

$\cancel{K_f} - K_i + \cancel{U_f} - \cancel{U_i} + U_s = 0$ ⇝ $K_i = U_s$

ϕ same 2

$\frac{1}{2}(m_1 + m_2) v_c^2 = \frac{1}{2} k x^2$

⇝ $x = \sqrt{\frac{m_1 + m_2}{k}}\, v_c = \sqrt{\frac{3 kg}{2000 kg m/s^2/m}}\ 2.67 m/s = \boxed{0.33 m}$ 2 1 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,

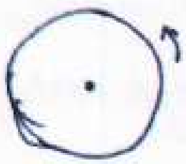
   ii Calculate the time required to complete the 40 revolutions,

   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

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

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

$\left(30 \times \frac{2\pi\,rad}{s}\right)^2 = \left(20 \times \frac{2\pi\,rad}{s}\right)^2 + 2\alpha\, 40 \times 2\pi\,rad \Rightarrow \alpha = 39.27\,rad/s^2$ (1) (1)

$\underline{\alpha = 6.25\,rev/s^2}$

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

$30\,rev/s = 20\,rev/s + 6.25\,rev/s^2\, t \rightarrow \underline{t = 1.6\,s}$ (1) (1)

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

$20\,rev/s = 0 + 6.25\,rev/s^2\, t \rightarrow \underline{t = 3.2\,s}$ (1)

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

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

(1)

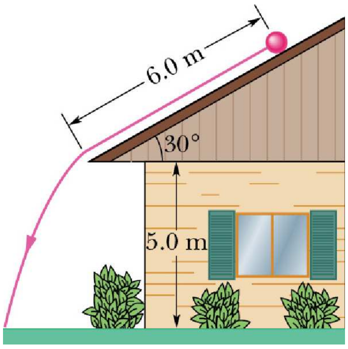
v) $R = 10\,cm = 0.1\,m$, $a_r = \frac{v^2}{R} = \frac{(\omega R)^2}{R} = \omega^2 R = (20\,rev/s)^2\, 0.1\,m$

$\underline{= 40\,m/s^2}$ (1)

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

(1) (1)

5. In figure, a solid cylinder of radius 10 cm and mass 12 kg starts from rest and rolls without slipping a distance L = 6.0 m down a roof that is inclined at the angle $\theta = 30°$.

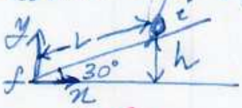


i What is the angular speed of the cylinder about its center as it leaves the roof?

ii The roof's edge is at height H=5.0 m. How far horizontally from the roof's edge does the cylinder hit the level ground?

Rolling Motion. Conservation of Emech

i) $\cancel{K_i} + U_i = K_f + \cancel{U_f}$ (3)



$h = L\sin 30$

$v = R\omega$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ (3)

$\cancel{m}gL\sin 30° = \frac{1}{2}\cancel{m}R^2\omega^2 + \frac{1}{2}\,\frac{1}{2}\cancel{m}R^2\omega^2 \sim \omega^2 = \frac{4}{3}\frac{L\sin 30°\, g}{R^2}$

$\sim \omega = \frac{2}{R}\sqrt{\frac{L\sin 30°}{3}}$ (3) $= \frac{2}{0.1m}\sqrt{\frac{6 * \sin 30° * 9.8\,m/s^2}{3}} \simeq 63\,rad/s$ (1)

ii)

$v = R\omega = (0.1m)(63\,rad/s) = 6.3\,m/s = v_0$ (2)

now, we have projectile motion

(1) $y - y_0 = v_{0y}t + \frac{1}{2}gt^2$ $\left\{ \begin{array}{l} v_{0x} = v_0\cos 30° \\ v_{0y} = v_0\sin 30° \end{array} \right.$

$5m - 0 = v_0\sin 30\,t + \frac{1}{2}gt^2$

$\rightsquigarrow 4.9t^2 + 3.15t - 5 = 0$ { Quadratic equation (3) $t_{12} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

(1) $\Rightarrow x - x_0 = v_0\cos 30\,t$

$= 63\,m/s \cos 30\; 0.74s$

$= 4.03m$ (2)

$t_{12} = \frac{-3.15 \pm \sqrt{3.15^2 - 4 \cdot 4.9 \cdot (-5)}}{2 \cdot 4.9}$

(1) $t_1 = 0.74s$ $\quad t_2 = \cancel{-1.38s}$