UNIVERSITY of GAZIANTEP, DEPT of ENGINEERING PHYSICS
EP 105 General Physics I, 2nd Exam, *FALL 2021*, Date: 21/12/2021,Duration: 90 min.

Name	
Surname	
Student ID	
Department	

Question	Mark
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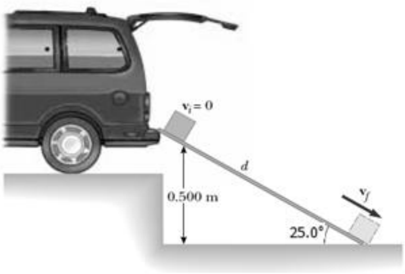
TOTAL	

- **CHEATING** is a **SERIOUS OFFENCE** and may lead to your **DISMISSAL** from the **UNIVERSITY**!
- The steps of solution of each problem should be shown clearly in the space given.
- Write your final result in a box and Numerical answers must be given with correct **SI units**.
- Take $g = 9.8\ m/s^2, \pi = 3,14$

QUESTION 1 (20 %)

A 3.00-kg crate slides down a ramp. The ramp is d=1.18m in length, 0.50 m height and inclined at an angle of 25.0°, as shown in the figure. The crate starts from rest at the top of the ramp, experiences a constant friction force of magnitude 5.00 N as it moves downward along the ramp. Use energy methods to determine



a) the initial mechanical energy (in Joules) of the crate at the top of the ramp,

b) the speed (in m/s) of the crate at the bottom of the ramp,

c) the final mechanical energy (in Joules) of the crate at the bottom of the ramp. (g=9.8 m/s^2)

Solution:

a)

$$E_i = K_i + U_i = 0 + U_i = mgy_i$$
$$= (3.00\ \text{kg})(9.80\ \text{m/s}^2)(0.500\ \text{m}) = 14.7$$

b) Using the work done by the frictional force

$$-f_k d = (-5.00\ \text{N})(1.18\ \text{m}) = -5.90\ \text{J}$$

The change in the mechanical energy of the crate when it gets the bottom of the ramp

The change in the mechanical energy of the crate when it gets the bottom of the ramp

$$E_f - E_i = \tfrac{1}{2} m v_f^2 - mgy_i = -f_k d$$

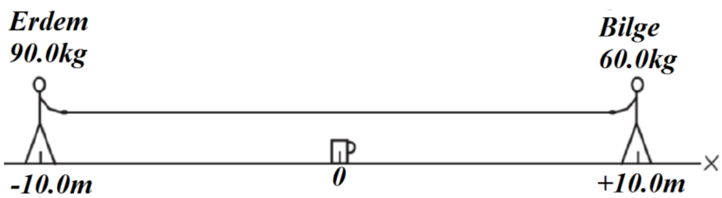
or

$$\tfrac{1}{2} m v_f^2 = 14.7\ \text{J} - 5.90\ \text{J} = 8.80\ \text{J}$$
$$v_f = 2.42\ \text{m/s}$$

c) $E_f = \tfrac{1}{2} m v_f^2 = 8.80\ \text{J}$

QUESTION 2 (20 %)

Erdem (mass 90.0 kg) and Bilge (mass 60.0 kg) are 20.0 m apart on a frozen lake. A cup of milk is between them. They pull on the ends of a light and massless rope stretched between them. When Erdem has moved 6.0 m toward the cup, *how far* and *in what direction* has Bilge moved due to cup?



SOLUTION:

The initial x-coordinate of the center of mass of Erdem and Bilge for their initial positions is

$$x_{cm} = \frac{(90.0\ \text{kg})(-10.0\ \text{m}) + (60.0\ \text{kg})(10.0\ \text{m})}{90.0\ \text{kg} + 60.0\ \text{kg}} = -2.0\ \text{m}$$

When Erdem moves to -4m, the center of mass does not move

$$x_{cm} = \frac{(90.0\ \text{kg})(-4.0\ \text{m}) + (60.0\ \text{kg})x_2}{90.0\ \text{kg} + 60.0\ \text{kg}} = -2.0\ \text{m}$$

$$x_2 = 1.0\ \text{m}$$

So, the final position of Bilge is 1.0 m away from the cup!

QUESTION 3 (20 %)

A 5.00-g bullet is shot through a 1.2-kg wood block suspended on a string 2.0 m long. The center of mass of the block rises a distance of 2.0 cm. If the initial speed of the bullet was 600 m/s,

a) What is the speed of the block after the collision?

b) What is the speed of the bullet as it emerges from the block?

SOLUTION:

Let +*x* be to the right. Let the bullet be *A*and the block be *B*. Let $V_B$be the velocity of the block just after the collision.

a)Apply conservation of energy to the motion of the block after the collision:

$$K_B = U_B \; ; \qquad \frac{1}{2} m_B {V_B}^2 = m_B g h \; ; \quad V_B = \sqrt{2gh} = \sqrt{2(9.8)(0.02)} = 0.63\, m\, .$$

b)Applyconservation of momentum to the collision:

$$V_{Af} = \frac{m_A V_A - m_B V_{Bf}}{m_A} = \frac{(5 \times 10^{-3} kg)\left(600 \frac{m}{s}\right) - (1.2\, kg)(0.63\, m/s)}{5 \times 10^{-3} kg} = 448.8\, m/s$$

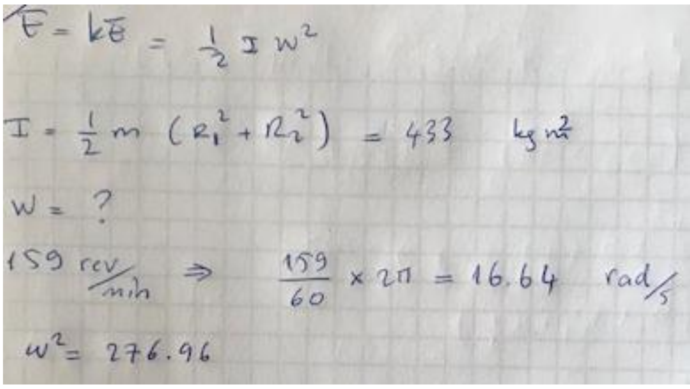
QUESTION 4 (20 %)

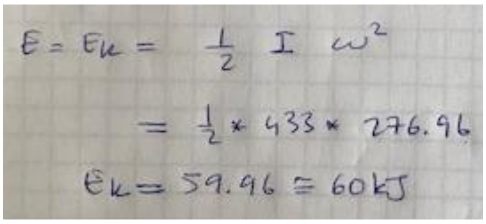
Calculate the kinetic energy of a 200 kg flywheel that has the form of a hollow cylinder with inner radius 1.2 m and outer radius 1.7 m spinning at 159 rpm.

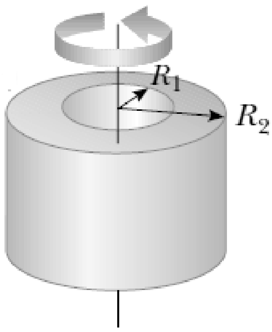
Hollow cylinder

$I_{CM} = \frac{1}{2} M({R_1}^2 + {R_2}^2)$

SOLUTION:


E = KE = ½ I w²
I = ½ m (R₁² + R₂²) = 433 kg m²
w = ?
159 rev/min ⇒ 159/60 × 2π = 16.64 rad/s
w² = 276.96


E = E_k = ½ I ω²
= ½ × 433 × 276.96
E_k = 59.96 ≅ 60kJ



QUESTION 5 (20 %)

The angular coordinate of a rolling ball with radius 40 cm is given as $\theta(t) = 25 + 3t + 4t^2 - 2t^3$ (rad) where t is in second. Find

a) the average angular velocity and acceleration between $t_1 = 0$ and $t_2 = 1\, s$,

b) the linear acceleration of the object at $t = 3\, s$.

SOLUTION:

a) $\theta(t) = 3\,t + 4\,t^2 - 2\,t^3 + 25 \rightarrow \theta(0) = 25\, rad \;\; and\; \theta(1) = 30\, rad$

$$w = \frac{d\theta}{dt} = 3 + 8t - 6\,t^2 \;\rightarrow w(0) = 3\frac{rad}{s} \;\; and\; w(1) = 5\frac{rad}{s}$$

$$\bar{w} = \frac{\theta(1) - \theta(0)}{1 - 0} = \frac{30 - 25}{1 - 0} = 5\, rad/s$$

$$\bar{\alpha} = \frac{w(1) - w(0)}{1 - 0} = \frac{5 - 3}{1 - 0} = 2\frac{rad}{s^2}$$

b)

$$\alpha = \frac{d^2\theta}{dt^2} = 8 - 12t \;\rightarrow \alpha(3) = -28\frac{rad}{s^2} \;\; and\; a = \alpha\, R = -28\frac{rad}{s^2} * 0.4\, m = -11.2\frac{m}{s^2}$$