UNIVERSITY OF GAZIANTEP
DEPARTMENT OF ENGINEERING PHYSICS
EP 105 General Physics I
Second Midterm Exam *FALL SEMESTER*

Date: 11/12/2018 Time: 08:30 Duration: 100 min.

Ques.	Mark
1	
2	
3	
4	
5	
Total	

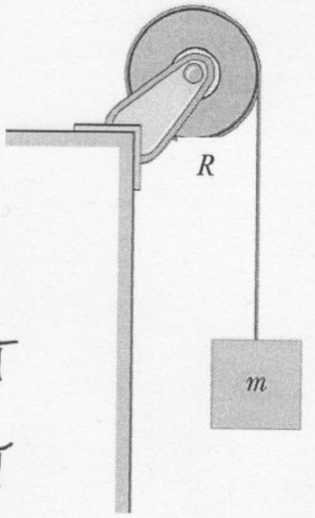
EDUCATION : ☐ 1st Ed. ☐ 2nd Ed.
DEPARTMENT : ☐ CE ☐ MME ☐ IE ☐ ME ☐ TE

Name	Surname	Student No	Signature
—	SOLUTIONS —		

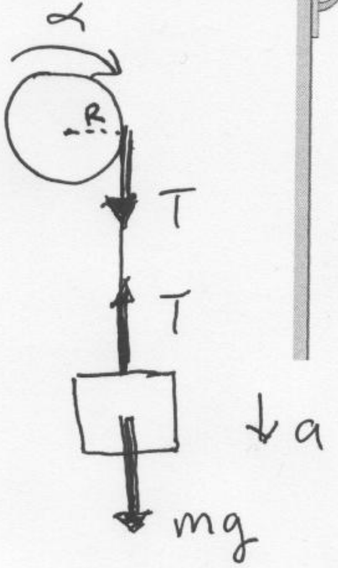
- Cheating is a serious offence and may lead to your dismissal from the university.
- Ignore air resistance in all problems unless otherwise stated.
- Write clearly your solutions steps to the space provided and results to the boxes.
- Constants: $g = 9.8\ m/s^2$, $\pi = 3.141593$
- Conversions: 1 mm=10^{-3} m, 1 cm= 10^{-2} m,1nm =10^{-9} m, 1 km = 10^3 m, 1 h = 3600 s, 1 min = 60 s, 1 rev = 2π rad.

QUESTION 1 (20 %)

Figure shows a uniform disk of radius $R = 0.1$ m mounted on a fixed horizontal axle. A block with mass $m = 2$ kg hangs from a massless cord that is wrapped around the rim of the disk. The cord does not slip and there is no friction at the axle. The mass m falls down at a constant acceleration of $a = 5\ m/s^2$.



(a) Calculate the rotational inertia of the disk about the axle.



Newton's 2nd law:

$$mg - T = ma \quad \text{(for mass)}$$

$$\tau = I\alpha \quad \text{(for disk)}$$

$$TR = I\frac{a}{R}$$

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$$T = mg - ma$$

$$I = \frac{TR^2}{a} = \frac{(mg-ma)R^2}{a}$$

$$= \frac{(2\times 9.8 - 2\times 5)(0.1)^2}{5}$$

$$= 0.0192\ kg.m^2$$

$I = 0.0192\ kg.m^2$

(b) Find the tension in the cord while the mass is falling down.

$$T = mg - ma = 9.6\ N$$

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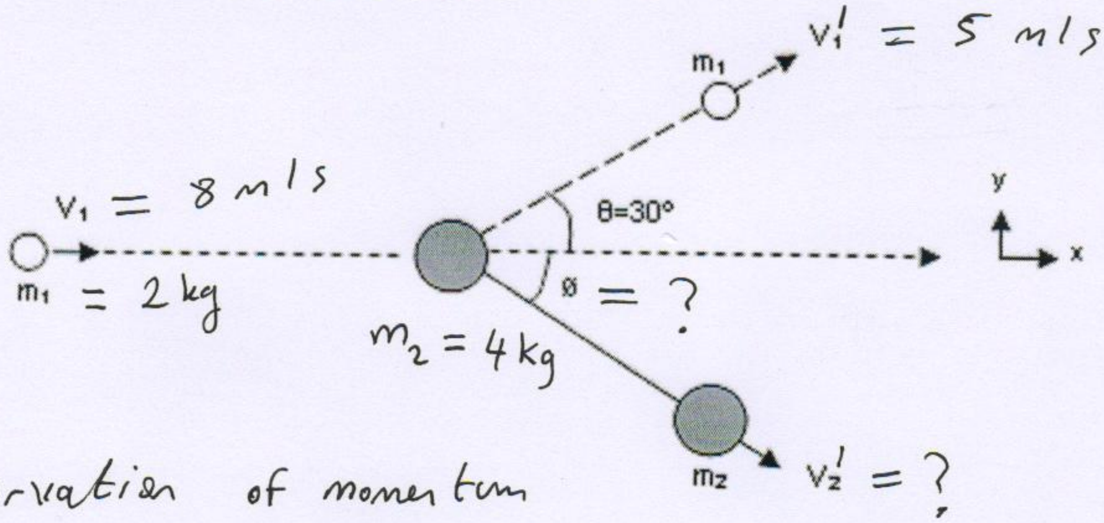
or

$$T = \frac{Ia}{R^2} = 9.6\ N$$

$T = 9.6\ N$

QUESTION 2 (20 %)

A ball of mass $m_1 = 2\ kg$ and speed $v_1 = 8\ m/s$ makes a collision with a target particle ($m_2 = 4\ kg$) at rest. After the collision the ball m_1 is scattered with $v_1' = 5\ m/s$ and $\theta = 30^0$, as shown. Find the direction (φ) and the velocity of the ball m_2 after the collision.



Conservation of momentum

- in x-direction:

$$m_1 v_1 + 0 = m_1 v_1' \cos\theta + m_2 v_2' \cos\phi$$

$$(2)(8) = (2)(5)\cos 30 + 4 v_2' \cos\phi$$

$$1.835 = v_2' \cos\phi \quad (1)$$

(5)

- in y-direction:

$$0 = m_1 v_1' \sin\theta - m_2 v_2' \sin\phi$$

$$0 = (2)(5)\sin 30 - 4 v_2' \sin\phi$$

$$1.250 = v_2' \sin\phi \quad (2)$$

(5)

If you divide Eq(2) by Eq(1)

$$\tan\phi = \frac{1.250}{1.835} = 0.681 \rightarrow \phi = 34.3^\circ$$

or $\phi = 0.6$ rad.

(5)

from eq (1)

$$v_2' = \frac{1.835}{\cos\phi} = \frac{1.835}{\cos(34.3)} = 2.2\ m/s$$

(5)

$\phi = 34.3^\circ$	$v_2' = 2.2\ m/s$

QUESTION 3 (20 %)

A bicycle wheel has an initial angular velocity of 1.5 rad/s. Angular acceleration of the wheel is constant and equal to 0.3 rad/s^2.

(a) What is the angular velocity (in rad/s) of the wheel at time $t = 2.5$ s?

$$\omega = \omega_0 + \alpha t$$
$$= 1.5 + (0.3)(2.5)$$
$$= 2.25 \text{ rad/s}$$

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$\omega = 2.25$ rad/s

(b) Through what angle (in rad) has the wheel turned between $t = 0$ and $t = 2.5$ s?

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$
$$= 0 + (1.5)(2.5) + \frac{1}{2}(0.3)(2.5)^2$$
$$= 4.69 \text{ rad}$$

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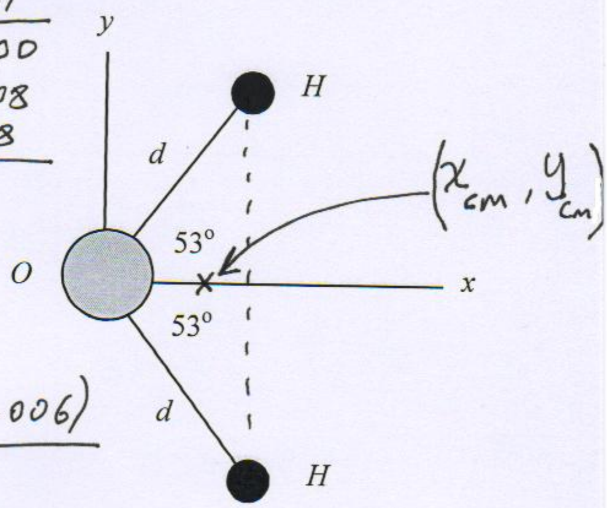
$\theta = 4.69$ rad

QUESTION 4 (20 %)

A water molecule consists of an oxygen atom with two hydrogen atoms bound to it as shown in Figure. The angle between the two bonds is 106°. If the bonds are $d = 0.1$ nm long, where is the center of mass of the molecule? Masses of Hydrogen and Oxygen are 1.674 x10^{-27} kg and 26.567x10^{-27} kg respectively.

Particle	$m \times 10^{-27}$ kg	x (nm)	y (nm)
1	26.567	0.000	0.000
2	1.674	0.006	0.008
3	1.674	0.006	-0.008
sum =	29.915		



$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$
$$= \frac{0 + (1.674)(0.006) + (1.674)(0.006)}{29.915}$$
$$= 0.0067 \text{ nm}$$

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$$y_{cm} = \frac{\sum m_i y_i}{\sum m_i} = \frac{0 + (1.674)(0.008) + (1.674)(-0.008)}{29.915}$$
$$= 0$$

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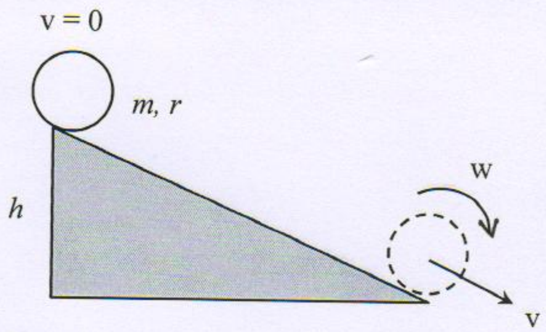
$x_{cm} = 0.0067$ nm

$y_{cm} = 0.0000$

QUESTION 5 (20 %)

A 5.2 kg hoop (ring) which has a radius of $r = 13$ cm is released at the top of an inclined surface of $h = 3.2$ m above the ground. Assume that the hoop rolls down without slipping. [$I = m r^2$]



(a) Calculate the center of mass velocity of the hoop at the bottom of the incline. Use Conservation of Energy principle.

Gravitational Potential Energy = Translational K.E + Rotational K.E

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

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}(mr^2)\frac{v^2}{r^2}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$

$$gh = v^2$$

$$v = \sqrt{gh} = \sqrt{(9.8)(3.2)}$$

$$= 5.6 \text{ m/s}$$

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V = 5.6 m/s

(b) Calculate the angular velocity about center of mass of the hoop at the bottom of the incline.

$$\omega = \frac{v}{r} = \frac{5.6 \text{ m/s}}{0.13 \text{ m}} = 43.1 \text{ rad/s}$$

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ω = 43.1 rad/s