Kuwait University — Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Fall Semester
Final Exam
Saturday, Dec 24, 2022
8:00 – 10:00 a.m.

Student's Name: ……………………………………………………………………………

Student's Number: …………………………………………… Section: ……………………

Choose your Instructor's Name:

Dr. Hala Al- Jassar
Dr. Tareq Alrefai
Dr. Fatema Al Dosari
Dr. Belal Salameh
Dr. Abdul Khaleq
Dr. Nasser Demir
Dr. Ruqayyah Askar
Dr. Bedoor Alkurtass

Grades: **For instructors use only**

#	SP1	SP2	SP3	SP4	SP5	SP6	SP7	LP1	LP2	LP3	Q1	Q2	Q3	Q4	Total
Pts	3	3	3	3	3	3	3	5	5	5	1	1	1	1	40

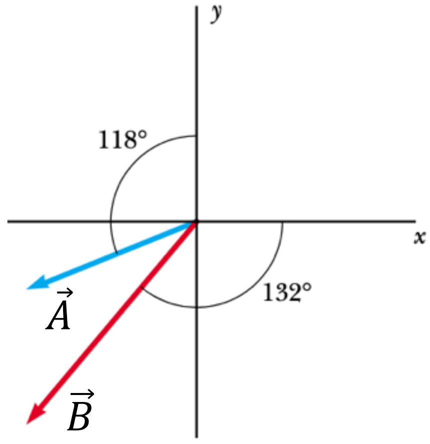
Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 40 points as arranged in the above table.
3. **Give your final answer in the correct units.**
4. Assume g = 10 m/s^2.
5. Mobiles smart watches are **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Short Problems (3 points each)

SP1. In the figure $|\vec{A}| = 15, |\vec{B}| = 22$, **find the scalar product ($\vec{A} \cdot \vec{B}$) of the two vectors.**



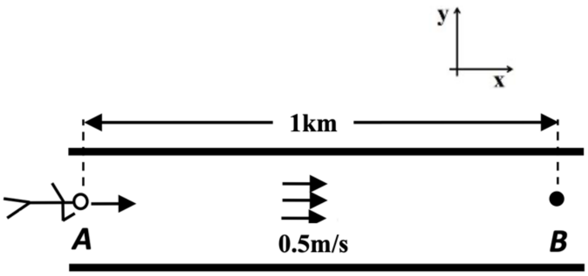
$\phi = 270° - 118° - 132° = 20°$

$\vec{A} \cdot \vec{B} = AB \cos\phi$

$= (15)(22) \cos 20°$

$= 310.1$

SP2. A river has a steady speed of $0.5\, m/s$. A student swims upstream a distance of $1\, km$. If the student can swim at a speed of $1.2\, m/s$ in still water, **how long does the trip take?**

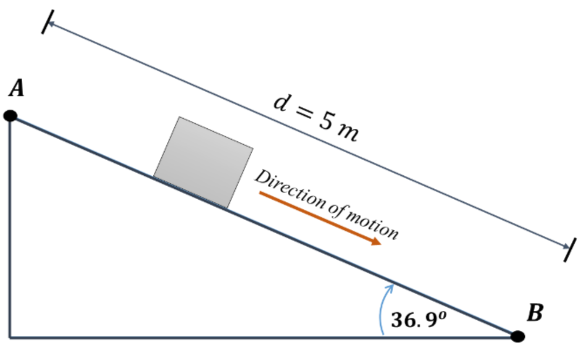


S: Student, R: River, E: Earth

$\vec{v}_{S/E} = \vec{v}_{S/R} + \vec{v}_{R/E} = 1.2 + 0.5 = 1.7\, m/s$

$t = \dfrac{d}{v_{S/E}} = \dfrac{1000}{1.7} = 588\, s$

SP3. A box ($m = 20\, kg$) **starts from rest** at point A and slides down on **a <u>rough surface</u>.** The coefficient of kinetic friction between the box and the surface is $\mu_k = 0.3$ and the distance from A to B is $d = 5\, m$, as shown. Find the **change (loss) in total mechanical energy between A and B ($E_B - E_A$).**



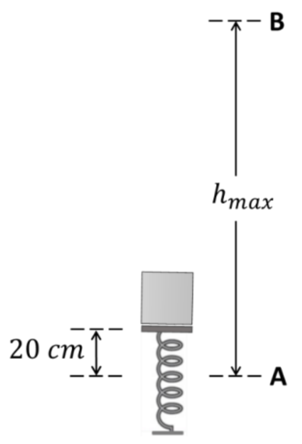
$n = mg \cos 36.9^o$

$W_{f_k} = -\mu_k\, n\, d = -\mu_k\, (mg \cos 36.9^o)\, d$

$= -(0.3)(20)(10)\ \cos 36.9^o\ (5) = -240\, J$

$\Delta E = W_{f_k} = -240\, J$

SP4. A block of mass $0.4\ kg$ compresses a spring ($k = 370\ N/m$) **a distance** $x = 20\ cm$, then the block is **released from rest** at point A. The block reaches the maximum height at point B. **Find the maximum height (h_{max}) of the block.** Ignore air resistance.



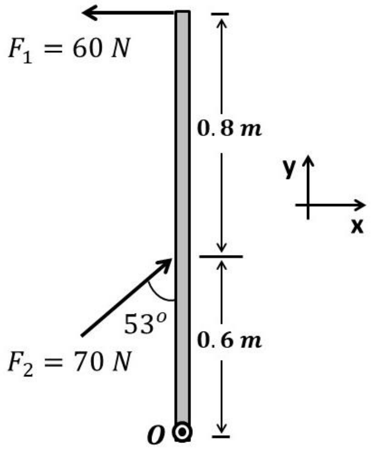
$E_i = E_f$

$\frac{1}{2}kx^2 = mgh_{max}$

$\frac{1}{2}(370)(0.2)^2 = (0.4)(10)h_{max}$

$h_{max} = 1.85\ m$

SP5. A thin massless rod in the xy plane is acted on by two forces as shown in the figure. **Calculate the net torque about point O and specify its direction.**



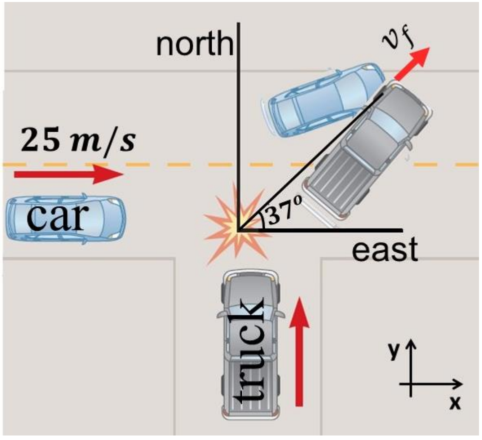
$\vec{\tau}_{net} = \vec{\tau}_1 + \vec{\tau}_2$

$= r_1F_1\sin(90^o) - r_2F_2\sin(53^o)$

$= 1.4(60)(1) - (0.6)(70)(0.8) = 50.5\ N\cdot m$

The rod rotates counterclockwise.

<u>SP6.</u> A 1200 kg car travelling east at 25 m/s collides with a 1600 kg truck travelling north. After the collision, the vehicles stick togother and move as shown. **<u>Find the final speed (v_f) of the wreckage.</u>**



$$m_1 v_{1_{xi}} + m_2 v_{2_{xi}} = (m_1 + m_2) v_f \cos(37^o)$$

$$1200\ (25) + 0 = (2800) v_f \cos(37^o)$$

$$v_f = \frac{1200\ (25)}{(2800)\cos(37^o)} = 13.4\ m/s$$

<u>SP7.</u> An object of mass 2 kg moves along the x-axis. A net force acts on it **along the <u>positive</u> x-axis** with the expression for the force given by $F(t) = t^3 - 3t^2 + 2$, where t is measured in seconds and F is measured in N. If the object moves at 3 m/s in the **<u>negative</u> x-axis** at $t = 0\ s$, **<u>find its velocity at $t = 4$ seconds</u>**.

$$\vec{J} = \Delta\vec{p}$$

$$\vec{J} = \int_{t=0}^{t=4} \vec{F}(t)dt = \int_{t=0}^{t=4} (t^3 - 3t^2 + 2)\ \hat{\imath}\ dt = \left[\frac{t^4}{4} - t^3 + 2t\right]_0^4 \hat{\imath} = 8\ \hat{\imath}\ kg \cdot m/s$$

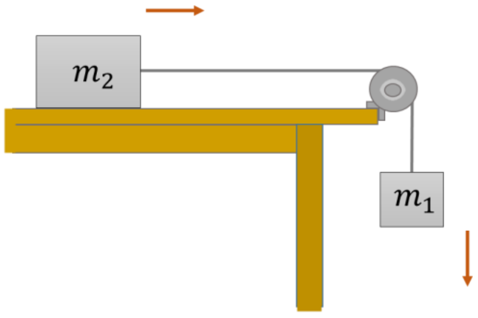
$$\vec{J} = m\Delta\vec{v}$$

$$\vec{v}_f = \vec{v}_i + \frac{\vec{J}}{m} = -3\hat{\imath} + \frac{8\hat{\imath}}{2} = 1\ \hat{\imath}\ \text{m/s}$$

Part II: Long Problems (5 points each)

LP1. Two blocks ($m_1 = 3\ kg$, $m_2 = 6\ kg$) are connected by a light rope passing over **a massless**, frictionless pulley. A constant horizontal **friction force** ($\mu_k = 0.6$) acts on block 2 as it slides on the table. **The two blocks move with initial speed v_i and come to rest after moving a distance 2 m.**

(a) Find the acceleration of the system.



For M_{total} :

$$\sum F = M_{total}\ a$$

$$m_1 g - f_k = M_{total}\ a$$

$$30 - (0.6)(6)(10) = 9\ a$$

$$a = -0.67\ m/s^2$$

(b) Find the tension in the rope.

For m_1:

$$\sum F = m_1\ a$$

$$m_1 g - T = m_1\ a$$

$$30 - T = (3)(-0.67)$$

$$T = 32\ N$$

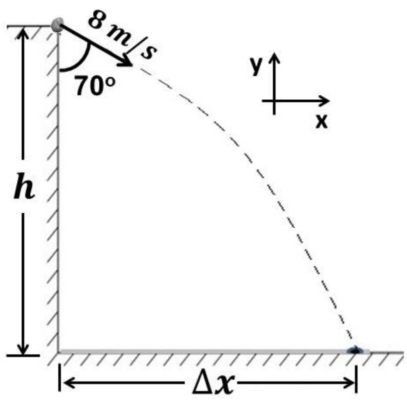
(c) Find the initial speed of the two blocks (v_i).

$$v_f^2 = v_o^2 + 2\ a\ \Delta x$$

$$0 = v_o^2 + 2\ (-0.67)\ (2) \quad \Rightarrow \quad v_o = 1.63\ m/s$$

LP2. A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 8 m/s, as shown. It strikes the ground 3 s later.

(a) How far horizontally from the base of the building does the ball strike the ground?



$$\Delta x = (v_0 \cos \alpha_0)t$$
$$= [8 \cos(20°)](3)$$
$$= 22.6\ m$$

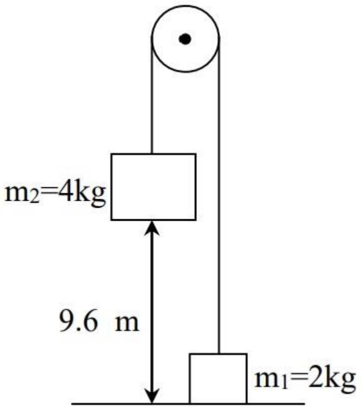
(b) Find the height (h) from which the ball was thrown.

$$v_{0y} = -v_0 \sin \alpha_0 = -8 \sin(20.0°) = -2.74 m/s$$
$$\Delta y = v_{0y} t - \frac{1}{2} g t^2$$
$$= (-2.74)(3) - \frac{1}{2}(10)(3)^2$$
$$= -53.2\ m$$
$$h = 53.2\ m$$

(c) What is the velocity of the ball in unit vector notation just before it hits the ground?

$$v_x = v_0 \cos \alpha_0 = 8 \cos(20.0°) = 7.5\ m/s$$
$$v_y = v_{0y} - gt$$
$$= -2.74 - (10)(3) = -32.7\ m/s$$
$$\vec{v} = (7.5\ \hat{\imath} - 32.7\ \hat{\jmath})\ m/s$$

LP3. The frictionless heavy disk in the figure has radius $R = 0.3\,m$ and a moment of inertia $I = 1.62\ kg \cdot m^2$. The rope does not slip on the disk rim. The masses m_1 and m_2 are released from rest.



(a) Find the speed of m_2 just before it strikes the ground.

$$E_i = E_f$$

$$m_2gh = m_1gh + \frac{1}{2}(m_1 + m_2)v_f^2 + \frac{1}{2}I\omega_f^2$$

$$(m_2 - m_1)gh = \frac{1}{2}\left(m_1 + m_2 + \frac{I}{R^2}\right)v_f^2$$

$$(4 - 2)(10)9.6 = \frac{1}{2}\left(2 + 4 + \frac{1.62}{0.3^2}\right)v_f^2$$

$$v_f = 4 \text{ m/s}$$

(b) Find the rotational kinetic energy of the pulley just before the block m_2 strikes the ground.

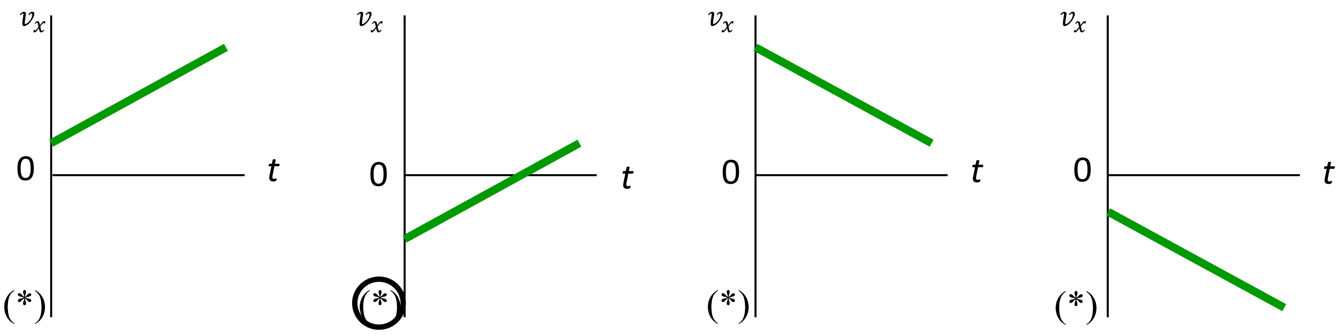
$$K = \frac{1}{2}I\omega^2 = \frac{1}{2}I\left(\frac{v}{R}\right)^2 = \frac{1}{2}(1.62)\left(\frac{4}{0.3}\right)^2 = 144 \text{ J}$$

(c) Find the work done by gravity on m_1 during this motion.

$$w_{mg}(on\ m_1) = -m_1g\ y = -(2)(10)(9.6) = -192\ J$$

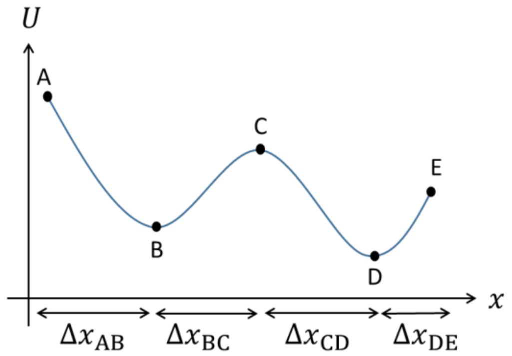
Part III: Questions (Choose the correct answer, one point each)

Q1. An object moves along the x-axis with constant acceleration. The initial velocity is negative, and the acceleration is positive. **Which of the following $v_x - t$ graphs best describes this motion?**



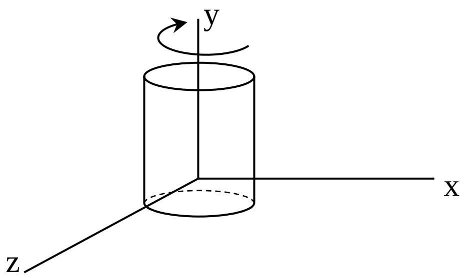
Q2. The **potential energy U** with respect to position x is given by the following diagram. **In which regions is the force positive ($F_x > 0$)?**

* Δx_{AB} and Δx_{BC}
* Δx_{CD} and Δx_{DE}
* Δx_{AB} and Δx_{CD}
* Δx_{BC} and Δx_{DE}



Q3. A cylinder is rotating **clockwise** about the y axis as shown with **increasing** angular speed. **The direction of the angular acceleration is**

* $\hat{k}$
* $-\hat{k}$
* $\hat{j}$
* $-\hat{j}$



Q4. Which of the following statements is true for an **elastic collision**?

* The momentum of the system is conserved, but the kinetic energy of the system is not conserved.
* Neither the momentum nor the kinetic energy of the system is conserved.
* The kinetic energy of the system is conserved but the momentum of the system is not conserved.
* Both the kinetic energy and momentum of the system are conserved.