# Kuwait University Physics Department

# Physics 101

Spring Semester

Second Midterm Exam

Thursday, July 01, 2021

7:00 pm – 08:30 pm

Student's Name: ……..…….…… Serial Number: ….……

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

| | |
|---|---|
| Dr. Ahmed Al-Jassar | Dr. Tareq Al Refai |
| Dr. Hala Al-Jassar | Dr. Abdul Khaleq |
| Dr. Fatema Al Dosari | Dr. Belal Salameh |
| Dr. Nasser Demir | |

## For Instructors use only

Grades:

| # | Q1 | Q2 | Q3 | SP1 | SP2 | SP3 | SP4 | SP5 | SP6 | SP7 | LP1 | LP2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pts | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 25 |
| | | | | | | | | | | | | | |

**Important**:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 25 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 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: Questions (Choose the correct answer, one point each)

**Q1.** A car traveling at a speed **v** on a horizontal road can stop in a minimum distance **d**. **What would be the car's minimum stopping distance if it was traveling at a speed of 2v?**

* $\sqrt{2}d$ * 2d (*) 4d * 8d

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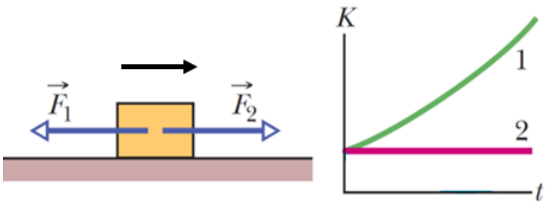
**Q2.** Two horizontal forces acting on a block which **is sliding <u>to the right</u>** across a horizontal frictionless surface. The graph shows two curves of the block's kinetic energy K versus time t. The relation between $F_1$ and $F_2$ for each curve is:




* curve 1: $F_1 = F_2$ , curve 2: $F_1 > F_2$
* curve 1: $F_1 > F_2$ , curve 2: $F_1 = F_2$
(*) curve 1: $F_1 < F_2$ , curve 2: $F_1 = F_2$
* curve 1: $F_1 < F_2$ , curve 2: $F_1 > F_2$

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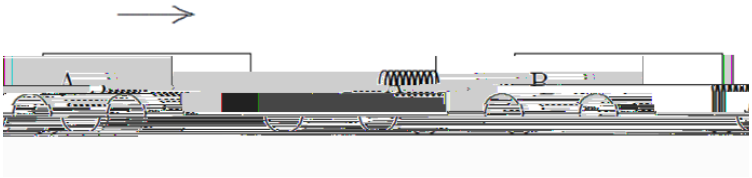
**Q3.** Cart A ($m_A = 2kg$) is initially moving to the right collides with cart B ($m_B = 3kg$) which has a spring bumper and is initially at rest as shown. **Which of the following statements is correct when the compression of the spring is maximum?**




* cart B is still at rest
* cart A has come to rest
* the two carts have the same kinetic energy
(*) the kinetic energy of the system is minimum

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## Part II: Short Problems (2 points each)

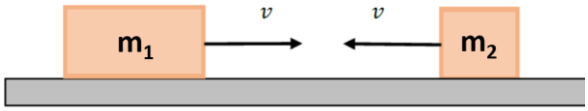
**SP1**. A motor is able to pull a 370 kg box along a horizontal rough floor ($\mu_k$ = 0.45) at a constant speed of 4 m/s. **What is the power of the motor?**

F = $\mu_k$ mg = 16650 N

$P = |\vec{F}||\vec{v}| = (\mu_k\, mg)\, v = 0.45\ (370)\ (10)\ (4) = 6660$ W

Answer: P = 6660 W

**SP5.** Two blocks ($m_1 = 6$ kg and $m_2 = 2$ kg) move on a frictionless horizontal surface. Initially, each block is moving with speed of $v = 3$ m/s as shown. If the blocks **stick together** after the collision, **what is the kinetic energy of the system after the collision?**




$$m_1 v_{1xi} + m_2 v_{2xi} = M v_{xf}$$

$$v_{xf} = \frac{m_1 v_{1xi} + m_2 v_{2xi}}{M} = \frac{6(3) + 2(-3)}{8} = +1.5\ m/s$$

$$K_f = \frac{1}{2} M v_{xf}^2 = 9\ J$$

Answer: $K_f = 9\ J$

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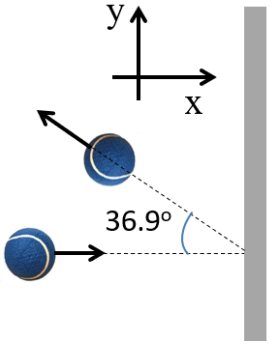
**SP6.** A ball ($m = 0.1\ kg$) hits a wall horizontally with a speed of 4 m/s and bounces back with the same speed in a direction 36.9° with the horizontal as shown. **Find the magnitude of the impulse on the ball.**




$$\vec{v}_i = +4\hat{\imath}\ m/s$$

$$\vec{v}_f = (-4\cos\ 36.9^o\ \hat{\imath} + 4\ sin\ 36.9^o \hat{\jmath})\ m/s = (-3.2\hat{\imath} + 2.4\hat{\jmath})\ m/s$$

$$\vec{J} = \Delta\vec{p} = m\left(\vec{v}_f - \vec{v}_i\right) = (-0.72\hat{\imath} + 0.24\hat{\jmath})\ N \cdot s$$

$$\left|\vec{J}\right| = \sqrt{0.72^2 + 0.24^2} = 0.76\ N \cdot s$$

Answer: $\left|\vec{J}\right| = 0.76\ N \cdot s$

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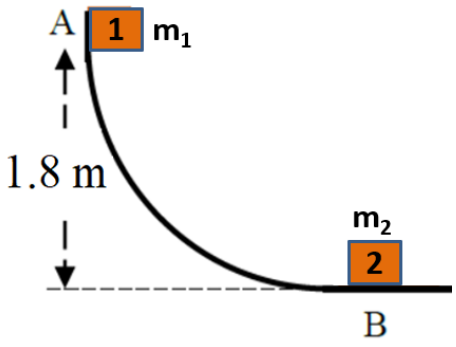
**SP7.** Block 1 ($m_1 = 2$ kg) is released from rest at point A and slides down a frictionless track then collides with block 2 ($m_2 = 3$ kg) that is stationary at point B. After the collision, block 1 **rebounds** with speed of 3 m/s, **find the speed of block 2 after the collision.**




$$m_1 gh = \frac{1}{2} m_1 v_{1i}^2 \Rightarrow v_{1i} = \sqrt{2gh} = 6\ m/s$$

$$m_1 v_{1xi} + m_2 v_{2xi} = m_1 v_{1xf} + m_2 v_{2xf}$$

$$(2)(6) + 0 = 2(-3) + 3v_{2xf}$$

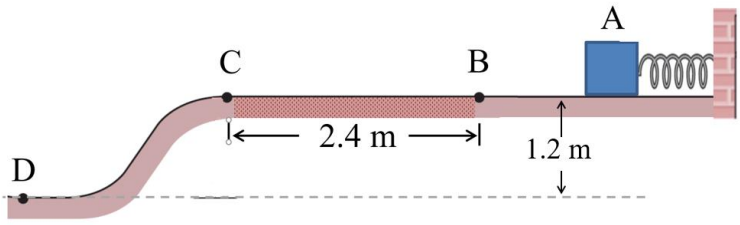
$$v_{2xf} = \frac{12 + 6}{3} = 6\ m/s$$

Answer: $v_{2xf} = 6\ m/s$

## Part III: Long Problems (4 points each)

**LP1.** A block ($m = 0.5\ kg$) is **released from rest** at point A when the spring (k = 900 N/m) is compressed a distance of $x = 0.2\ m$. The block passes point B when the spring is relaxed and continues to move along the path shown in the figure. **The path is frictionless except the section between points B and C where $\mu_k = 0.4$.**

**a) Find the work done by gravity on the block between points A and D.**




$W_{mg} = +mgh = 0.5(10)(1.2) = 6\ J$

Answer: $W_{mg} = 6\ J$

**b) Find the work done by friction force on the block.**

$W_{f_k} = -\mu_k mgd_{BC} = -0.4(0.5)(10)(2.4) = -4.8\ J$

Answer: $W_{f_k} = -4.8\ J$

**c) Find the speed of the block at point D.**

$E_D - E_A = W_{f_k}$

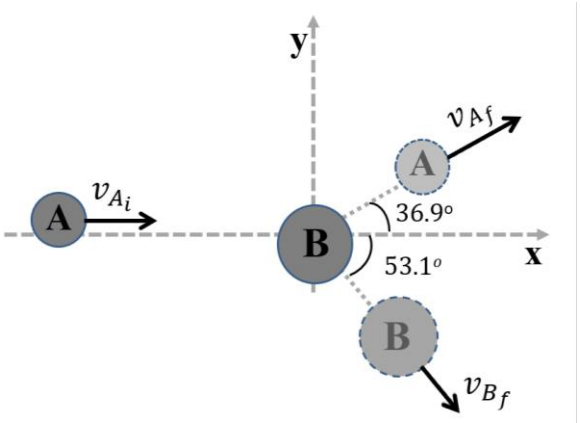
$\frac{1}{2}mv_D^2 - \left(\frac{1}{2}kx_A^2 + mgh\right) = -4.8$

$0.25v_D^2 - (18 + 6) = -4.8 \Rightarrow v_D = 8.8\ m/s$

Answer: $v_D = 8.8\ m/s$

**LP2.** The figure shows an elastic collision between two balls each of mass 0.2 kg on a frictionless horizontal surface. Ball A moves at 5 m/s strikes the stationary ball B. After the collision, ball A moves at 4 m/s in the direction shown in the figure.

**a) What is the speed of ball B after the collision?**




$$K_{A_i} + K_{B_i} = K_{A_f} + K_{B_f}$$

$$\frac{1}{2}mv_{A_i}^2 + 0 = \frac{1}{2}mv_{A_f}^2 + \frac{1}{2}mv_{B_f}^2$$

$$v_{A_i}^2 = v_{A_f}^2 + v_{B_f}^2 \Rightarrow v_{B_f} = \sqrt{v_{A_i}^2 - v_{A_f}^2} = \sqrt{5^2 - 4^2}$$

$$= 3\ m/s$$

**Or**

$$\sum p_{x_i} = \sum p_{x_f}$$

$$mv_{A_{xi}} + mv_{B_{xi}} = mv_{A_{xf}} + mv_{B_{xf}}$$

$$5 + 0 = 4\cos(36.9^o) + v_{Bf}\cos(53.1^o)$$

$$v_{Bf} = \frac{5 - 4\cos(36.9^o)}{\cos(53.1^o)} = 3\ m/s$$

**Or**

$$\sum p_{y_i} = \sum p_{y_f}$$

$$mv_{A_{yi}} + mv_{B_{yi}} = mv_{A_{yf}} + mv_{B_{yf}}$$

$$0 = 4\sin(36.9^o) - v_{Bf}\sin(53.1^o)$$

$$v_{Bf} = \frac{4\sin(36.9^o)}{\sin(53.1^o)} = 3\ m/s$$

Answer: $v_{Bf} = 3\ m/s$

**b) What is the magnitude of the average force exerted by ball A on ball B if the collision contact time is 0.002 s.**

$$\Delta\vec{p}_B = \vec{F}_{av}\,\Delta t \quad \Rightarrow mv_{B_f} - 0 = F_{av}\,\Delta t \quad \Rightarrow F_{av} = \frac{mv_{B_f}}{\Delta t} = \frac{0.2(3)}{0.002} = 300\ N$$

Answer: $F_{av} = 300\ N$

**c) If the collision takes place at the origin (0, 0), find the position of the center of mass for the two balls two seconds after the collision.**

$\vec{v}_{A_f} = (4\ cos\alpha)\hat{\imath} + (4\ sin\alpha)\hat{\jmath} = (3.2\hat{\imath} + 2.4\hat{\jmath})\ m/s,$ $\quad \vec{r}_A(2s) = \vec{v}_{A_f}t = \ (6.4i + 4.8j)\ m$

$\vec{v}_{B_f} = (3\ cos\beta)\hat{\imath} - (3\ sin\beta)\hat{\jmath} = (1.8\hat{\imath} - 2.4\hat{\jmath})\ m/s,$ $\quad \vec{r}_B(2s) = \vec{v}_{B_f}t = \ (3.6i - 4.8j)\ m$

$$\vec{r}_{cm} = \frac{m\,\vec{r}_A + m\,\vec{r}_B}{2m} = 5\hat{\imath}\ m$$

Answer: $\vec{r}_{cm} = 5\hat{\imath}\ m$