Kuwait University **Physics Department**

Physics 101

Spring Semester
Final Exam
Sunday, May 28, 2017
3:00 pm – 5:00 pm

Model Answer

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

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

Choose your Instructor's Name:

Prof. Yacoub Makdisi	Dr. Abdul Mohsen
Dr. Hasan Raafat	Dr. Tareq Al Refai
Dr. Hala Al-Jassar	Dr. Nasser Demir
Dr. Ahmed Al-Jassar	Dr. Abdul Khaleq
Dr. Fatema Al Dosari	Dr. Belal Salameh

For Instructors use only

Grades

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

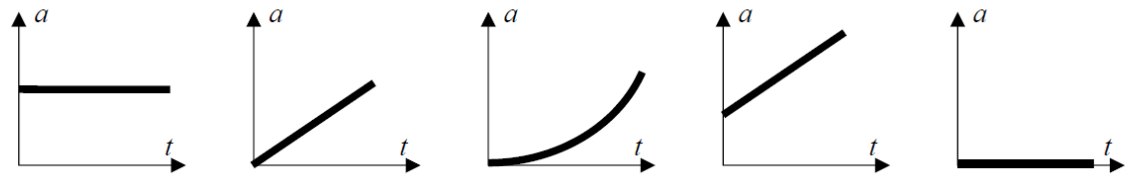
Important:

1. Answer all questions and problems.
2. Full mark = 40 points as arranged in the above table.
   i) 4 **Q**uestions
   ii) 7 **S**hort **P**roblems
   iii) 3 **L**ong **P**roblems.
3. No solution = no points.
4. **Use SI units.**
5. Check the correct answer for each question.
6. Assume g = 10 m/s^2.
7. Mobiles are **strictly prohibited** during the exam.
8. Programmable calculators, which can store equations, are not allowed.
9. **Cheating accidents will be processed according to the university rules.**

GOOD LUCK

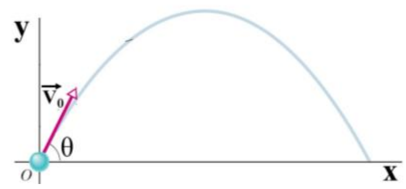
Part I: Questions (Choose the correct answer, one point each)

Q1. A particle is moving in **a straight line at a constant velocity**. Which of the following figures represents the acceleration of the particle as a function of time?



*   *   *   *   ⊛ *

Q2. The work done by gravity during **the descent** of a projectile:



⊛ * is positive   * is negative   * is zero

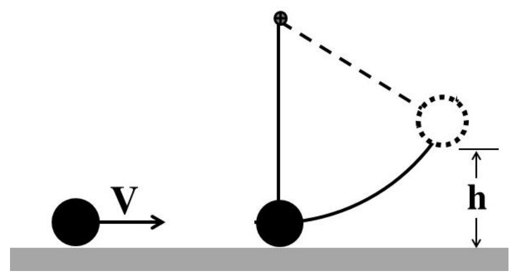
* its sign depends on the direction of the y axis

* its sign depends on the direction of both the x and y axes

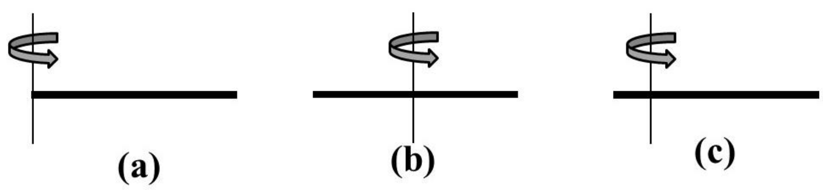
Q3. A ball of mass m and speed V undergoes **a head on elastic** collision with a stationary pendulum ball of the **same mass** as shown. The ball of the pendulum will rise to **a maximum height h which equals:**

* $\frac{V^2}{g}$ * $\frac{2V^2}{g}$ ⊛ * $\frac{V^2}{2g}$

* $\frac{2V^2}{3g}$ * $\frac{5\,V^2}{2\,g}$



Q4. Three identical rods (same mass and length), each can rotate about the vertical axis as shown in the figure. **The relation between the moments of inertia of the rods is:**



⊛ * $I_b < I_c < I_a$ * $I_b < I_a < I_c$ * $I_a < I_c < I_b$ * $I_a < I_b < I_c$ * $I_c < I_a < I_b$

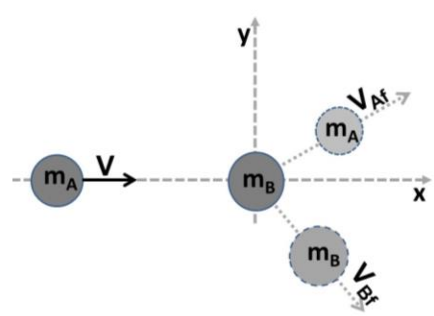
Part II: Short Problems (3 points each)

SP1. A and B are two balls ($m_B = 2m_A$), ball B is stationary and ball A is moving toward it with a speed V on a frictionless horizontal surface as shown. After the collision, the velocity of A is $\vec{V}_{Af} = (3.2\hat{\imath} + 2.4\hat{\jmath})\ m/s$ and the velocity of B is $\vec{V}_{Bf} = (1.8\hat{\imath} - 1.2\hat{\jmath})\ m/s$. **Find the velocity (in m/s) of the center of mass <u>before the collision</u> in unit vector notation.**

$$\vec{V}_{cm_i} = \vec{V}_{cm_f}$$

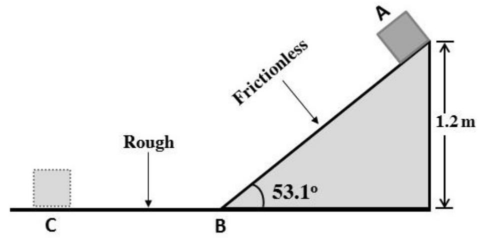
$$= \frac{m_A\vec{V}_{A_f} + m_B\vec{V}_{B_f}}{m_A + m_B}$$

$$= \frac{m_A(3.2\,\hat{\imath} + 2.4\hat{\jmath}) + 2m_A(1.8\,\hat{\imath} - 1.2\hat{\jmath})}{3m_A} = 2.27\hat{\imath}\ m/s$$



Answer: $2.27\hat{\imath}\ m/s$

SP2. A 2 kg block is released from rest at point A and slides down **a frictionless** incline. Then it moves on a **rough** horizontal surface ($\mu_k = 0.4$) from B to C where it comes to rest. **Find the distance (in m) between B and C.**



$$E_f - E_i = -f_k d$$

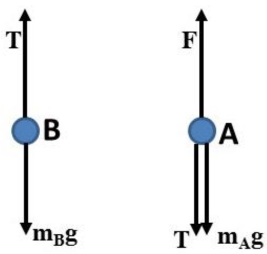
$$0 - (mgh) = -\mu_k mgd \quad \Longrightarrow \quad d = \frac{h}{\mu_k} = \frac{1.2}{0.4} = 3m$$

Answer: $3m$

SP3. Two boxes, A and B, are connected to each end of a light rope, a constant upward force of 120 N is applied to box A as shown in the figure. **<u>The system accelerates downward</u>** at a rate of 2 m/s^2. If the tension in the rope connecting the two boxes is 80 N. **Draw the free body diagram of each box and find the mass (in kg) of box A and of box B.**

<u>For box A</u> $m_A g + T - F = m_A a$

$$m_A = \frac{F-T}{g-a} = 5\ kg$$



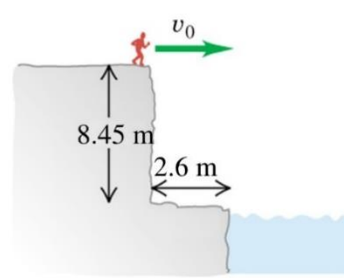
<u>For box B</u> $m_B g - T = m_B a$

$$m_B = \frac{T}{g-a} = 10\ kg$$

Answer: $m_A = 5\ kg$

$m_B = 10\ kg$

SP4. A 50 kg swimmer dives off a cliff with a running horizontal leap, as shown in the figure. **What must her minimum speed (in m/s) be just as she leaves the top of the cliff** so that she will miss the ledge at the bottom.



$$\Delta y = V_{yi} t - \frac{1}{2} g t^2$$

$$-8.45 = -5t^2 \ \Longrightarrow t = \sqrt{\frac{8.45}{5}} = 1.3 \text{ s}$$

$$\Delta x = V_{xi} t$$

$$V_{xi} = \frac{\Delta x}{t} = \frac{2.6}{1.3} = 2\ m/s$$

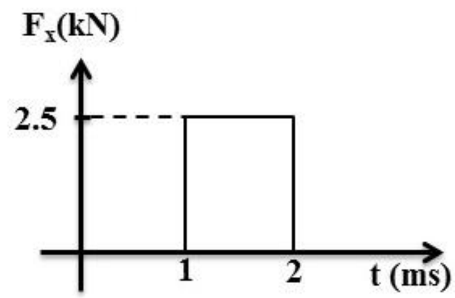
Answer: $2\ m/s$

SP5. A 0.5 kg stone is sliding to the right on a frictionless horizontal surface at 6 m/s when it is suddenly struck by an object that exerts a large horizontal force on it for a short period of time. The figure shows the magnitude of this force as a function of time. Just after the force stops acting, **find the magnitude of the stone's velocity (in m/s) if the force acts to the right.**

$$\Delta P = F\Delta t = Area = 2.5\ kg\ m/s$$

$$\Delta P = m(V_f - V_i) \Rightarrow V_f = \frac{\Delta P}{m} + V_i = \frac{2.5}{0.5} + 6 = 11\ m/s$$

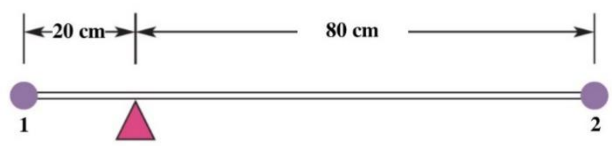
$$V_f = 11\ m/s$$



Answer: $11\ m/s$

SP6. Two identical particles each of mass m are fixed to the ends of a rigid **massless rod** as shown in the figure. The rod is held horizontally on a base and then released. **Find the magnitudes of the initial angular acceleration (in rad/s²) of the system?**

$$\Sigma\tau = I\alpha$$



$$mg(0.8) - mg(0.2) = [m(0.8)^2 + m(0.2)^2]\alpha$$

$$\alpha = \frac{g(0.8-0.2)}{(0.8)^2+(0.2)^2} = 8.8\ \ rad/s^2$$

Answer: $8.8\ rad/s^2$

SP7. A light rope is wrapped around a cylinder (R=0.2 m, I =0.04 kgm²) and passes over **a massless pulley**. A 3 kg box is suspended from the free end of the rope as shown in the figure. The cylinder and the pulley turn without friction about their centers. The box is released from rest and descends as the rope unwraps from the cylinder. **Find the speed (in m/s) of the box as it has fallen 2.5 m.**

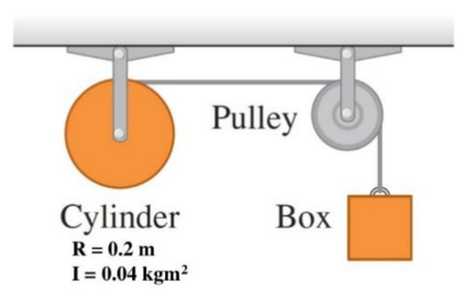
$$E_i \quad = \quad E_f$$

$$mgh = \frac{1}{2}\ mV^2 + \frac{1}{2}\ I\ \left(\frac{V}{R}\right)^2$$

$$mgh = \left(\frac{1}{2}m + \frac{1}{2}\frac{I}{R^2}\right)V^2$$

$$V = \sqrt{\frac{2\ mgh}{\left(m+\frac{I}{R^2}\right)}}$$

$$= \sqrt{\frac{2(3)(10)(2.5)}{\left(3+\frac{0.04}{(0.2)^2}\right)}} = 6.12\ m/s$$



Answer: $6.12\ m/s$

Part III: Long Problems (5 points each)

LP1. A wheel of radius 0.2 m starts from rest and rotates with constant angular acceleration to reach an angular speed of 12 rad/s in 3 s.

a) Find the magnitude of the angular acceleration (in rad/s^2) of the wheel.

$$\omega_f = \omega_i + \alpha t$$

$$12 = 0 + \alpha(3) \quad \Longrightarrow \quad \alpha = 4\, rad/s^2$$

Answer: $4\, rad/s^2$

b) How many revolutions will the wheel make during this time interval?

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$$

$$= 0 + \frac{1}{2}(4)(3)^2 = 18\, rad$$

$$n = \frac{\Delta\theta}{2\pi} = \frac{18}{2(3.14)} = 2.87 \text{ revolutions}$$

Answer: 2.87 revolutions

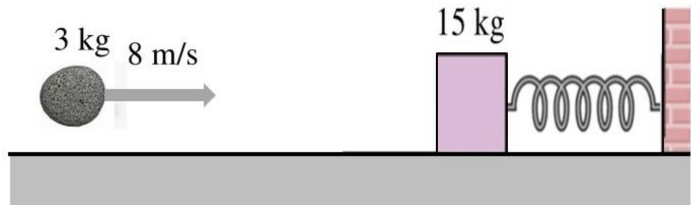
c) Find the magnitude of the centripetal acceleration (in m/s^2) of a point at the rim of the wheel at t=3 s.

$$a_c = R\omega^2 = 0.2\,(12)^2 = 28.8 \;\; m/s^2$$

Answer: 28.8 m/s^2

LP2. A 15 kg block rests on a frictionless horizontal surface and is attached to a light horizontal spring of force constant (k=1500 N/m) as shown in the figure. Suddenly it is struck by a 3 kg stone traveling horizontally at 8 m/s to the right. After the collision, the stone rebounds at 2 m/s horizontally to the left. Find:

a. The speed (in m/s) of the block immediately after the collision.



$$m_1 V_{1xi} + 0 = m_1 V_{1xf} + m_2 V_{2xf} \quad \Rightarrow V_{2xf} = \frac{m_1(V_{1xi} - V_{1xf})}{m_2} = \frac{3(8--2)}{15} = 2\ m/s$$

Answer: $2\ m/s$

b. The magnitude of the impulse (in N · s) exerted on the block by the stone.

$$\vec{J} = \Delta\vec{P} = m_2(\vec{V}_{2f} - \vec{V}_{2i}) = 15(2-0) = 30\ N\cdot s$$

$$J = 30\ N\cdot s$$

Answer: $30\ N\cdot s$

c. The maximum distance (in m) that the block will compress the spring after the collision.

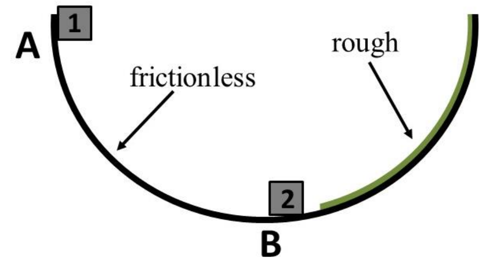
$$E_f = E_i$$

$$\frac{1}{2}kx^2 = \frac{1}{2}m_2V^2$$

$$x = \sqrt{\frac{m_2V^2}{k}} = \sqrt{\frac{15(2)^2}{1500}} = 0.2\ m$$

Answer: $0.2\ m$

LP3. Two identical blocks ($m_1=m_2=0.2$ kg), block 1 is released from rest at point A in the top edge of the frictionless part of hemispherical bowl of radius R = 5 m. Block 2 rests at point B at the frictionless bottom of the bowl as shown in the figure. The two blocks **collide and stick together at the bottom of the bowl.**



a. **Find the speed (in m/s) of the combined blocks immediately after the collision.**

For block 1:

$$E_B = E_A$$
$$\frac{1}{2}m\,V_{1B}^2 = mgR$$
$$V_{1B} = \sqrt{2gr} = \sqrt{2(10)(5)} = 10\;m/s$$

$$mV_{1i} + 0 = 2mV_f \quad \Rightarrow V_f = \frac{V_{1i}}{2} = 5\;m/s$$

Answer: 5 m/s

b. **Calculate the normal force (in N) on the combined blocks immediately after the collision.**

$$n - 2mg = 2m\frac{V_f^2}{R}$$

$$n = 2m\left(g + \frac{V_f^2}{R}\right) = 0.4\left(10 + \frac{5^2}{5}\right) = 6\;N$$

Answer: 6 N

c. **If the combined mass rises to a maximum height of 80 cm above point B on the rough portion of the hemisphere. Calculate the work (in J) done by friction during this motion.**

$$E_f - E_i = w_{f_k}$$
$$(2m)gh - \frac{1}{2}(2m)V^2 = w_{f_k}$$
$$0.4(10)(0.8) - \frac{1}{2}(0.4)(5)^2 = -1.8\;J$$

Answer: $-1.8\;J$