Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Summer Semester

Second Midterm Exam

Saturday, July 15, 2023

9:00 AM – 10:30 AM

Student's Name: …… Serial Number: ……

Model Answer

Student's Number: …… Section: ……

Instructors: Drs. Al Dosari, Al Jassar, Al Smadi, Salameh

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	SP6	LP1	LP2	Q1	Q2	Q3	Q4	Q5	Total
Pts	2	2	2	2	2	2	4	4	1	1	1	1	1	25

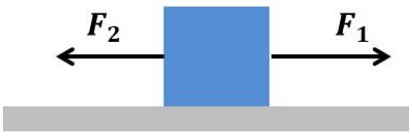
Important:

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: Short Problems (2 points each)

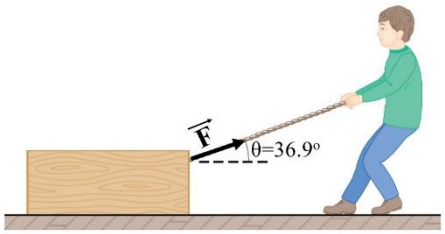
SP1. Two forces $F_1 = 20\,N$ and F_2 act on a $5\,kg$ block that is moving to **the right** on **a frictionless** horizontal surface with a constant acceleration of $a = 1.2\,m/s^2$. **Find the magnitude of the force F_2.**



$F_1 - F_2 = ma$

$F_2 = F_1 - ma = 20 - (5)(1.2) = 14\,N$

SP2. A block of mass ($m = 30\,kg$) is initially **at rest** on a horizontal **rough** surface. The coefficients of friction between the block and surface are (μ_s= 0.5 and μ_k= 0.4). A child pulls the rope by a force $|\vec{F}| = 130\,N$, as shown. **Find the magnitude of the frictional force acting on the block. Is it static or kinetic.**

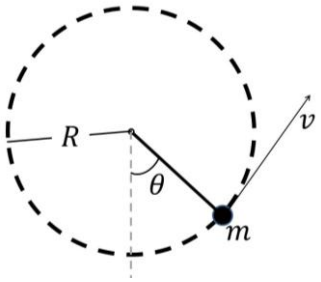


$f_{s,max} = \mu_s n = \mu_s(mg - F\sin(36.9^o)) = 111\,N$

$F\cos(36.9^o) = 104N \leq f_{s,max}$, so the block will stay at rest.

$f_s = F\cos(36.9^o) = 104N$, it is static friction.

SP3. A small ball ($m = 0.3\,kg$) attached to the end of a string, the ball rotates in a **vertical circle** ($R = 1.4\,m$), as shown. At the instant when $\theta = 37°$, the tension in the string is $T = 6\,N$. **What is the speed of the ball at this instant?**



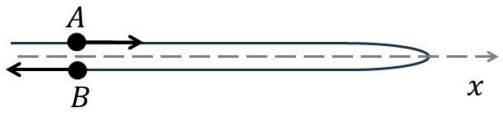
$F_r = \dfrac{mv^2}{R}$

$T - mgcos\theta = \dfrac{mv^2}{R}$

$6 - 0.3(10)\,cos37 = \dfrac{0.3 \times v^2}{1.4}$

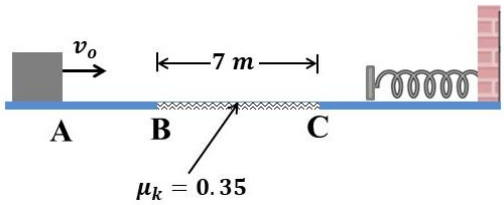
$v = 4.1\,m/s$

SP4. A 2 kg block is moving along the x-axis, as shown. At point A it is moving to **the right** at a speed of 4 m/s and at point B it is moving **to the left** at a speed of 4 m/s . **Find the total work done on the block between points A and B.**



$$W_{tot} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = 0$$

SP5. A block ($m = 3\ kg$) has a speed of $v_0 = 9\ m/s$ at point **A**. The block moves on a horizontal surface and runs into a relaxed spring ($k = 2400\ N/m$). The surface is **frictionless except the portion BC**, which is rough with $\mu_k = 0.35$. **Find the maximum compression of the spring.**



$$\mathrm{W_{tot}} = W_{mg} + W_n + W_{f_k} + W_{F_s} = \Delta K$$

$$\mathrm{W_{tot}} = 0 + 0 - \mu_k mgd - \frac{1}{2}kx_{max}^2 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_A^2$$

$$(-0.35)(30)(7) - (\tfrac{1}{2})(2400)(x_{max}^2) = 0 - (\tfrac{1}{2})(3)(9^2)$$

$$x_{max} = 0.2\ m$$

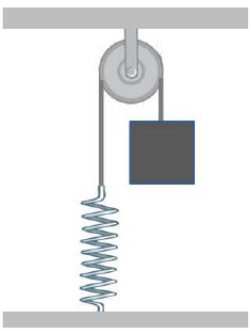
OR

$$E_f - E_f = W_{f_k}$$

$$\frac{1}{2}kx_{max}^2 - \frac{1}{2}mv_A^2 = -\mu_k mgd$$

$$\Rightarrow x_{max} = \sqrt{\frac{1}{k}(mv_A^2 - 2\mu_k mgd)} = \sqrt{\frac{1}{2400}\left(3(9^2) - 2(0.35)(30)(7)\right)} = 0.2\ m$$

SP6. A 16 Kg block is fastened to a light rope that passes over a massless frictionless pulley, the other end of the rope is fastened to a spring (with a spring constant k), as shown. The block is released **from rest** when the spring is **unstretched** and then researches a speed of $v = 2\ m/s$ after it has dropped a distance of 0.4 m. **Find the spring constant k.**



$$E_i = E_f$$

$$mgy_i = \frac{1}{2}kx_f^2 + \frac{1}{2}mv_f^2$$

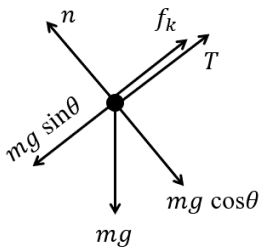
$$k = (2mgy_i - mv_f^2)/x_f^2 = 400N/M$$

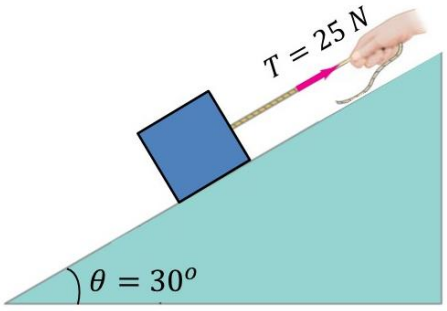
$$k = (2 \times 16 \times 10 \times 0.4 - 16 \times 4)/0.16 = 400N/m$$

Part II: Long Problems (4 points each)

LP1. A block of mass $m = 20\ kg$ is pulled up with a force, $T = 25\ N$ parallel to a **rough** incline, as shown. The coefficients of friction between the incline and block are ($\mu_s = 0.3$ and $\mu_k = 0.2$).

a) Draw a free-body diagram for the block. Note: the block is sliding down.





b) Find the acceleration of the block. Note: the block is sliding down.

$mgsin\theta - T - \mu_k mgcos\theta = ma$

$100 - 25 - (0.2)(200)(0.86) = 20a$

$a = 2\ \text{m/s}^2$

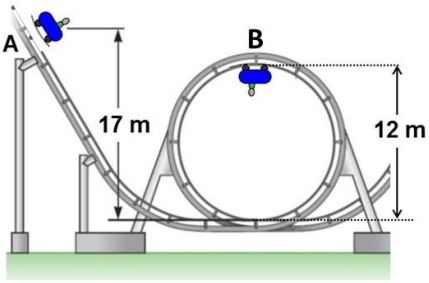
c) What value of the force T is required to move the block up the incline at a constant speed?

$T = \mu_k mgcos\theta + mgsin\theta$

$T = 134.6\ N$

LP2. A 250 kg roller coaster car starts from **rest at point A** and slides down the loop-the-loop shown. As it slides from **A** to **B**, the magnitude of the work **done by the friction** on the car is $W_{f_k} = 2400J$.

a) Find the total work done on the car when it slides from A to B



$$W_{tot} = W_{mg} + W_n + W_{f_k}$$

$$W_{tot} = mgh + 0 - 2400 = 250(10)(5) - 2400 = 10100J$$

b) Find the speed of the car at point B.

$$W_{tot} = \frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2 = \frac{1}{2} \times 250 \times v_B^2$$

$$10100 = \frac{1}{2} \times 250 \times v_B^2$$

$$v_B = 9\ m/s$$

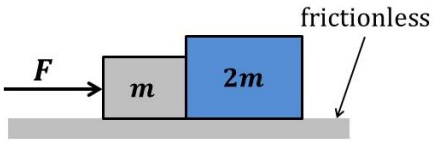
c) Find the normal force acting on the car by the track at point B?

$$n + mg = \frac{mv_B^2}{R}$$

$$n = \frac{mv_B^2}{R} - mg = 875\ N$$

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

Q1. A force $\boldsymbol{F}$ pushes a small box with mass $\boldsymbol{m}$ that is in contact with a larger box with mass $\boldsymbol{2m}$, as shown. The small box exerts a force $\boldsymbol{F_1}$ on the larger box, while the larger box exerts a force $\boldsymbol{F_2}$ on the smaller box. **Which one of the following statements is TRUE**?

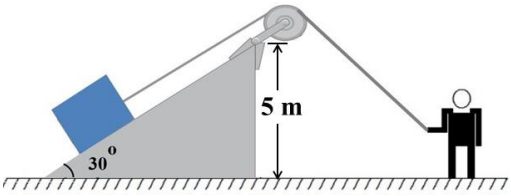


* $\boldsymbol{F_1 = 2F_2}$
* $\boldsymbol{F_1 = \frac{1}{2}F_2}$
* (*) $\boldsymbol{F_1 = F_2}$
* $\boldsymbol{F_1 = F_2 = 0}$

Q2. A particle is **moving in a uniform circular motion. Which one of the following statements is TRUE**?

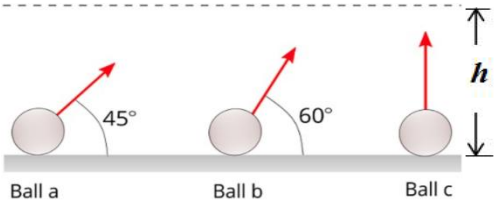
* $\vec{\boldsymbol{v}} = \boldsymbol{constant}$
* $\vec{\boldsymbol{a}} = \boldsymbol{constant}$
* (*) $|\vec{\boldsymbol{v}}| = \boldsymbol{constant}$
* $|\vec{\boldsymbol{a}}| = \boldsymbol{0}$

Q3. A man pulls a $100N$ crate up a frictioless 30° slope 5 m high, as shown. Assume that the crate moves at **constant speed**, the work done **by the man** is:



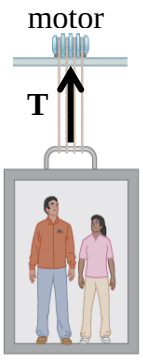
* $+250\,J$
* (*) $+500\,J$
* $-500\,J$
* $0\,J$

Q4. Three balls (a, b, and c) of **equal masses** are fired **from the ground** with **the same speed** but with different angles, as shown. Rank in order, from **largest to smallest**, the speeds of the balls v_a, v_b, and v_c, **as they cross the dashed horizontal line at height $\boldsymbol{h}$**.



* $v_a > v_b > v_c$
* $v_a > v_c > v_b$
* $v_c > v_b > v_a$
* (*) All the balls will have the same speed.

Q5. An elevator is carrying passengers, as shown. At the instant the speed of the elevator is v, **the highest power delivered by the motor occurs when the elevator**



* moves downward with increasing speed.
* (*) moves downward with decreasing speed.
* moves upward with decreasing speed.
* moves upward at constant speed.