PHYS 115 Midterm Exam #2 – Regular Version – Solutions

Description

This set of 1 statement of commitment to academic integrity and 9 questions is the second midterm exam for PHYS 115 Fall 2021 at the University of Saskatchewan.

1/3 of the exam mark is based on the answers for the 6 multiple-choice questions submitted through WebAssign. All 6 multiple-choice questions are weighted equally.

2/3 of the exam mark is based on the answers (submitted through WebAssign) and solutions (submitted through Canvas) for the 3 word problems. All 3 word problems are weighted equally.

Instructions

Answers for **all** questions need to be submitted in WebAssign.

For each of questions 8, 9, and 10, in addition to submitting your answers in WebAssign, write the complete solution, **including a diagram**, using the problem-solving method discussed in class.

Your solutions must use the same symbols as are used on the formulae sheet.

Formulas not on the Formulae Sheet must be derived.

Keep extra decimal places throughout your calculations, and then round-off your final answer to three significant figures.

Submit your answer to each question in WebAssign.

When you have finished the entire exam, scan your written work for questions 8 through 10 and submit a single multi-page PDF file using the link in the Canvas site for your section.

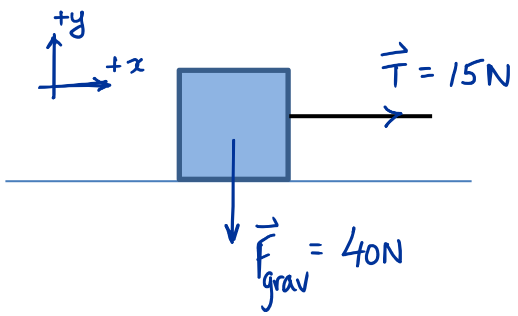
Your WebAssign submission is due no later than 90 minutes after the questions become available and your Canvas submission is due no later than 120 minutes after the questions become available.

1. UofS-P115-P117-Honour [4820285]
On my honour, I pledge that I will not give or receive aid during this assessment. I understand that I am expected to complete this assessment with no communication with other persons and no resource material other than the PHYS 115/117 Formulae sheet. I recognize that it is my responsibility to uphold academic integrity and I agree to follow the rules of this assessment and the guidelines laid forth in the policies of the University of Saskatchewan. Furthermore, I fully understand that disciplinary action may be taken against me if I am discovered to have communicated with another person or to have used an internet resource.

Yes, I understand and agree.

2. P115-2021-MT2-REG-A1 [5128430]
A block whose weight is 40 N rests on a horizontal surface. The coefficient of static friction between the block and the surface is 0.50. A string is attached to the block. The string is pulled horizontally with a force of 15 N. Which one of the following statements is correct?

- The force of friction cannot be determined because the normal force of the surface on the block is not known.
- The force of friction cannot be determined because the coefficient of kinetic friction is not given.
- The magnitude of the force of friction on the block is 15 N.
- The magnitude of the force of friction on the block is 20 N.
- The magnitude of the force of friction on the block is 5 N.



$\mu_s = 0.50$ $\qquad \Sigma F_y = 0 \Rightarrow n = F_{grav}$

$f_{s,max} = \mu_s n = (0.50)(40N) = 20N$

$T < f_{s,max} \quad \therefore f_s = T$

That is, f_s takes on the necessary value to prevent motion.

3. P115-2021-MT2-REG-A2 [5128431]
A block is sliding at constant speed down a ramp. Decide whether each of the following statements is true or false.

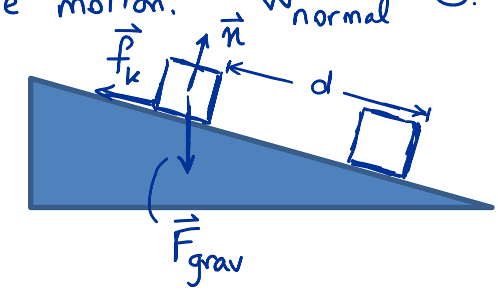
(a) The net work done on the block as it slides equals zero. True False

(b) The normal force does zero work on the block as it slides. True False

(c) The friction force does positive work on the block as it slides. True False

(a) constant speed $\Rightarrow$ constant KE $\Rightarrow \Delta KE = 0 \Rightarrow W_{net} = 0$.

(b) normal force is perpendicular to the motion. $\therefore W_{normal} = 0$.
$(W_{normal} = n \cos(90°) \cdot d = 0)$



(c) $W_{f_k} = f_k \cos(180°) d = -f_k d$

4. P115-2021-MT2-REG-A3 [5128435]

Two equal-mass balls, one blue and the other red, are dropped from the same height. Both balls bounce off the floor and rebound straight up. The rebounding blue ball reaches a greater height than the red ball. Which ball is subjected to a greater magnitude impulse during its collision with the floor?

- The red ball.
- Both balls are subjected to the same magnitude impulse.
- The answer cannot be determined without knowing the time interval that each ball is in contact with the floor.
- The blue ball.

Impulse-Momentum Theorem: $\vec{I} = \Delta\vec{p} = m\Delta\vec{v} = m(\vec{v}_f - \vec{v}_i)$

$\vec{v}_i = 0$ for both balls. $\therefore \vec{I} = m\vec{v}_f$

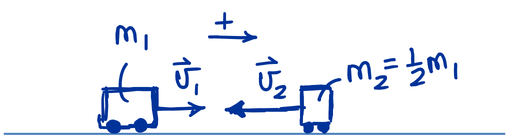
To reach a greater height after rebounding, $v_{f_b} > v_{f_r}$ where v_f is the speed with which the balls leave the floor.

Since $\vec{I} = m\vec{v}_f$ and $v_{f_b} > v_{f_r}$, $\vec{I}_b > \vec{I}_r$

5. P115-2021-MT2-REG-A4 [5128450]

Two carts on a frictionless track are traveling directly toward each other. The first cart has mass m_1 and speed v_1, the second cart has mass $m_2 = (½)m_1$ and speed $v_2 = 2v_1$. If they collide head-on and stick together, what can you say about the total momentum and total kinetic energy of the two-cart system? Ignore friction and air resistance. ("final" refers to after the collision and "initial" refers to before the collision.)

- The final momentum equals the initial momentum and the final kinetic energy equals the initial kinetic energy.
- The final momentum equals half the initial momentum and the final kinetic energy equals half the initial kinetic energy.
- The final momentum is zero and the final kinetic energy is zero.
- The final momentum is zero and the final kinetic energy equals the initial kinetic energy.
- The final momentum is zero and the final kinetic energy equals half the initial kinetic energy



$\vec{F}_{ext} = 0$ so momentum is conserved.

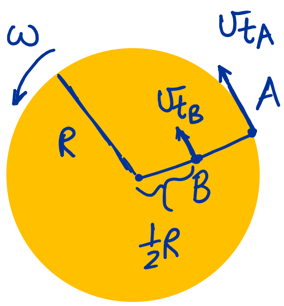
$\vec{p}_{tot_f} = \vec{p}_{tot_i} = m_1(+v_1) + (\frac{1}{2}m_1)(-2v_1) = 0$

Since the carts stick together, they have a common final velocity, v_f.

So $p_{tot_f} = (m_1+m_2)v_f$. Since $p_{tot_f} = 0$, $v_f = 0$, $\therefore KE_{tot_f} = 0$.

6. P115-2021-MT2-REG-A5 [5128454]
A disk rotates about an axis through its center. Point A is located on its rim and point B is located exactly halfway from the center toward the rim. What is the ratio ω_A/ω_B, of the angular velocity at A, ω_A, to that of the angular velocity at B, ω_B; and what is the ratio $\upsilon_{tA}/\upsilon_{tB}$, of the tangential velocity at A, υ_{tA}, to that of the tangential velocity at B, υ_{tB}?

$\omega_A/\omega_B = ½$ and $\upsilon_{tA}/\upsilon_{tB} = 1$
$\omega_A/\omega_B = 1$ and $\upsilon_{tA}/\upsilon_{tB} = 1$
$\omega_A/\omega_B = 1$ and $\upsilon_{tA}/\upsilon_{tB} = 2$
$\omega_A/\omega_B = 2$ and $\upsilon_{tA}/\upsilon_{tB} = 2$
$\omega_A/\omega_B = 2$ and $\upsilon_{tA}/\upsilon_{tB} = 1$



Angular velocity is the same for all points in a rotating rigid body.

$$\frac{\omega_A}{\omega_B} = 1.$$

$$\upsilon_{t_A} = R\omega_A = R\omega$$

$$\upsilon_{t_B} = \tfrac{1}{2}R\omega_B = \tfrac{1}{2}R\omega$$

$$\frac{\upsilon_{tA}}{\upsilon_{t_B}} = \frac{R\omega}{\frac{1}{2}R\omega} = 2.$$

7. P115-2021-MT2-REG-A6 [5128433]
A motor increases its speed from 100 rev/min to 500 rev/min in 20 seconds. If this is done with a constant angular acceleration, how many revolutions occur in this 20 s interval?

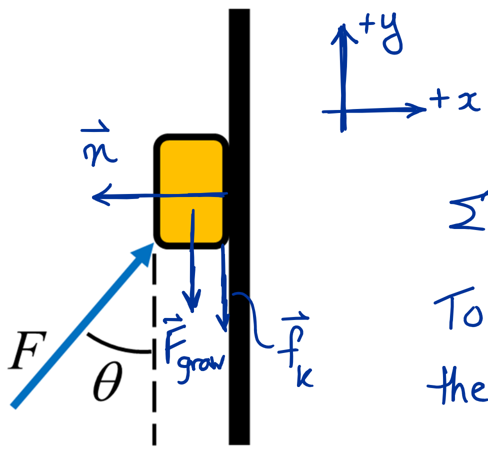
170 rev 200 rev 100 rev 6000 rev 67 rev

$$\Delta\theta = \tfrac{1}{2}(\omega_0 + \omega)t = \tfrac{1}{2}\left(100\,\frac{\text{rev}}{\text{min}} + 500\,\frac{\text{rev}}{\text{min}}\right)\left(20\,\text{s} \times \frac{1\,\text{min}}{60\,\text{s}}\right) = \tfrac{1}{2}\left(600\,\frac{\text{rev}}{\text{min}}\right)\left(\tfrac{1}{3}\,\text{min}\right)$$

$$\Delta\theta = 100\,\text{rev}$$

8. P115-2021-MT2-REG-B1 [5128436]

A sanding block is being pushed up a vertical wall by a force F that is being applied at an angle of θ = 25.3° to the vertical as shown in the diagram. The block is moving up the wall at a constant speed. The mass of the block is 0.522 kg and the coefficient of kinetic friction between the block and the wall is 0.873. Calculate the magnitude of the force F. To receive full marks, you must include a diagram showing the physical situation and your choice of coordinate system. *9.63 N*



Constant speed along the wall $\Rightarrow \sum\vec{F} = 0$

$\sum F_x = 0 \Rightarrow -n + F\sin\theta = 0 \Rightarrow n = F\sin\theta$

$\sum F_y = 0 \Rightarrow +F\cos\theta - F_{grav} - f_k = 0.$

To calculate F, use $f_k = \mu_k n = \mu_k F\sin\theta$ in the $\sum F_y = 0$ equation.

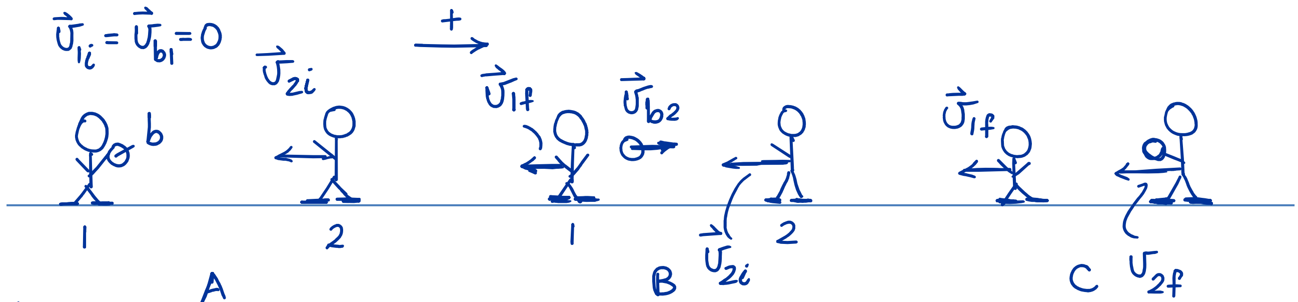
$$F\cos\theta - F_{grav} - \mu_k F\sin\theta = 0$$

$$F(\cos\theta - \mu_k\sin\theta) = F_{grav} \quad \text{and} \quad F_{grav} = mg$$

$$F = \frac{mg}{\cos\theta - \mu_k\sin\theta} = \frac{(0.522\text{ kg})(9.80\text{ m/s}^2)}{\cos(25.3°) - 0.873\sin(25.3°)} = \boxed{9.63\text{ N}}$$

9. P115-2021-MT2-REG-B2 [5128437]

A 45.5-kg person, initially at rest, throws a 0.172-kg snowball forward with a horizontal speed of 30.8 m/s. A second person, with a mass of 46.3 kg, catches the snowball. Both people are on skates. The first person is initially at rest, as mentioned, and the second person is initially moving with a speed of 1.04 m/s toward the first person. Disregard air resistance and the friction between the skates and the ice. Take the direction in which the snowball is thrown to be the positive direction. Indicate the directions of the final velocities with the signs of your answers. (a) Calculate the **velocity** of the first person immediately after they throw the snowball. (b) Calculate the **velocity** of the second person immediately after they catch the snowball. To receive full marks, you must include a diagram showing the physical situation and your choice of coordinate system. thrower: *-0.116 m/s*; catcher: *-0.922 m/s*



$\vec{F}_{ext} = 0$ horizontally, so momentum is conserved in the horizontal direction.

$$\vec{P}_{tot_A} = \vec{P}_{tot_B} \Rightarrow m_1 v_{1i} + m_b v_{b1} + m_2 v_{2i} = m_1 v_{1f} + m_b v_{b2} + m_2 v_{2i}$$

$$0 = m_1 v_{1f} + m_b v_{b2} \Rightarrow v_{1f} = \frac{-m_b v_{b2}}{m_1} = \frac{-(0.172\,kg)(30.8\,m/s)}{45.5\,kg}$$

$$\boxed{v_{1f} = -0.116\,m/s} \quad (-0.11643\,m/s)$$

second person catches snowball

$$\vec{P}_{tot_B} = \vec{P}_{tot_C} \Rightarrow m_1 v_{1f} + m_b v_{b2} + m_2 v_{2i} = m_1 v_{1f} + (m_b + m_2) v_{2f}$$

$$m_b v_{b2} + m_2 v_{2i} = (m_b + m_2) v_{2f} \Rightarrow v_{2f} = \frac{m_b v_{b2} + m_2 v_{2i}}{m_b + m_2}$$

$$v_{2f} = \frac{(0.172\,kg)(30.8\,m/s) + (46.3\,kg)(-1.04\,m/s)}{(0.172\,kg + 46.3\,kg)} = \boxed{-0.922\,m/s} \quad (-0.922155\,m/s)$$

Check: Does $\vec{P}_{totA} = \vec{P}_{totB}$? i.e. $m_2 v_{2i} \stackrel{?}{=} m_1 v_{1f} + (m_b + m_2) v_{2f}$;

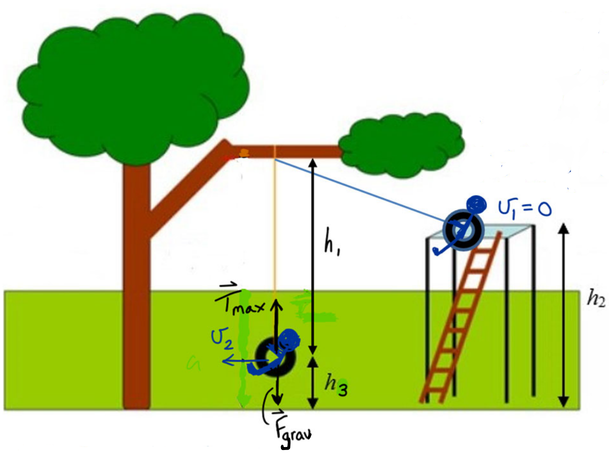
$$48.152\,kg\cdot m/s \stackrel{?}{=} 48.152\,kg\cdot m/s \checkmark$$

10. P115-2021-MT2-REG-B3 [5128434]

A tire is tied to a rope that is tied to the branch of a tree so that the tire swings in a circular trajectory of radius h_1 = 15.53 m. A child takes the tire to the top of a platform that is a height h_2 = 12.60 m above the ground, sits in the tire, and swings from rest from the platform. The combined mass of the tire and child is 42.7 kg. The rope is taut when the child leaves the platform and you may neglect the mass of the rope. At the bottom of the circular trajectory, the child and tire are a height h_3 = 0.97 m above the ground. To receive full marks, you must include a diagram showing the physical situation.

(a) Calculate the speed of the child/tire at the bottom of the circular trajectory. *15.1 m/s*

(b) Calculate the maximum tension in the rope as the child/tire swing back and forth. *1050 N*



maximum tension will occur when the child is moving fastest and when the weight force has its maximum component directed radially outward. This happens at the bottom of the swing trajectory.

(a) Apply Conservation of Mechanical Energy b/w the platform and the bottom of the trajectory.

$$W_{nc} = (KE_f + PE_f) - (KE_i + PE_i) \Rightarrow 0 = \frac{1}{2}mv_2^2 + mgh_3 - (0 + mgh_2)$$

$$\therefore mg(h_2 - h_3) = \frac{1}{2}mv_2^2 \Rightarrow v_2 = \sqrt{2g(h_2 - h_3)}$$

$$v_2 = \sqrt{2(9.80\,m/s^2)(12.60\,m - 0.97\,m)} = \boxed{15.1\,m/s}$$

(b) Applying Newton II for Circular Motion at the bottom of the trajectory:

$$\sum F_r = ma_c \Rightarrow T_{max} - F_{grav} = \frac{mv_2^2}{h_1} \Rightarrow T_{max} = mg + \frac{mv^2}{h_1} = m\left(g + \frac{v^2}{h_1}\right)$$

$$T_{max} = 42.7\,kg\left(9.80\,m/s^2 + \frac{(15.1\,m/s)^2}{15.53\,m}\right) = 1045\,N = \boxed{1.05 \times 10^3\,N}$$