PHY 211 – Exam 2 (Version 1)

Name (please print): Jack Laiho

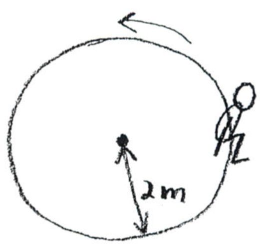
SUID: ______________

Please circle your TA's name: **Tyler** **Xingbo** **Zek**

It is very important that you print your name at the top of the exam page. Please do it before you read any questions!

Document your work. Use the back of each sheet if you run out of space.

1.[25 pts total] A merry-go-round of radius 2 m is rotating counter-clockwise at 10 rpm. A child is sitting on the outer edge of the merry-go-round. The merry-go-round is given a push giving it an angular acceleration of 0.4 rad/s^2. Right at the instant when the angular acceleration begins, calculate the following:



$\omega = 10 \frac{rev}{min} \frac{2\pi\, rad}{1\, rev} \frac{1\, min}{60\, s} = 1.05 \frac{rad}{s}$

$r = 2\, m$

a. [3 pts] What is the speed of the child?

$V = \omega r = 1.05 \frac{rad}{s} \times 2\, m = 2.09 \frac{m}{s}$

b. [3 pts] What is the angular velocity of the child in rad/s?

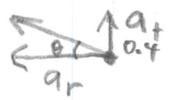
$\omega = 10 \frac{rev}{min} \frac{2\pi\, rad}{1\, rev} \frac{1\, min}{60\, s} = 1.05 \frac{rad}{s}$

c. [4 pts] What is the radial (centripetal) acceleration of the child?

$a_r = \frac{V^2}{r} = \frac{2.09^2}{2} = 2.18 \frac{m}{s^2}$

d. [10 pts] What is the total acceleration of the child, including the direction? Assume that the child is sitting at "3 o' clock" (as shown in the diagram) at the instant that the angular acceleration begins.

$$a = \sqrt{a_r^2 + a_t^2} = \sqrt{2.18^2 + 0.8^2} = 2.32 \frac{m}{s^2}$$



$$\tan\theta = \frac{a_t}{a_r} = \frac{0.8}{2.18} \Rightarrow \theta = 20.2^\circ$$

above -x-axis.

$$a_t = \alpha r = 0.4 \times 2 = 0.8$$

e. [5 pts] What is the speed of the child 5 seconds after the angular acceleration begins?

$$\omega_f = \omega_0 + \alpha t$$

$$V_f = \omega_f r = \omega_0 r + \alpha r t$$

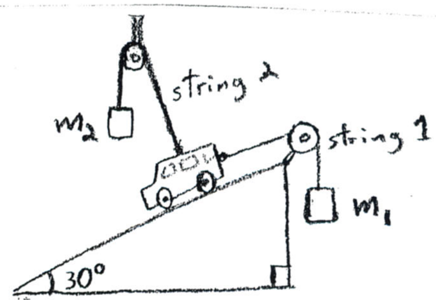
$$= 1.05 \times 2 + 0.4 \times 2 \times 5$$

$$= 6.1 \frac{m}{s}$$

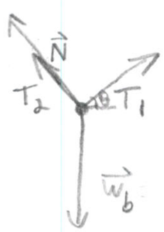
Name (please print): ______________________________

SUID: ____________

2. [25 pts total] A toy bus of mass 0.2 kg is at rest on an incline, with two strings attached to it, as shown in the diagram below. Masses 1 and 2 are not known. String 1 is parallel to the ramp, and string 2 is perpendicular to the ramp, as shown in the diagram. Assume that friction is negligible.



a. [4 pts] Draw the free-body diagram for the bus, labeling all forces that act on the bus.



$\theta = 30°$

$|\vec{w_b}| = m_b g$

$\Sigma \vec{F} = m\vec{a}$

b. [5 pts] What is the tension in string 1? What is the value of m_1?

$\Sigma F_y = m a_y = 0$

$-W \sin\theta + T_1 = 0$ $\qquad T_1 = m_1 g = 0.1 \times 9.8 = 0.98\ N$

$-m_b g \sin\theta + m_1 g = 0$

$m_1 = m_b \sin\theta = 0.2\ kg\ \sin\theta = 0.1\ kg$

c. [8 pts] What value of m_2 is needed so that the normal force that the ramp exerts on the bus is zero?

$\Sigma F_x = m a_x = 0$, $N = 0$ $\qquad T_2 = m_2 g$

$-m_b g \cos\theta + N + T_2 = 0$

$m_2 g = m_b g \cos\theta = 0.2\ kg\ \cos\theta = 0.17\ kg$

d. [4 pts] Suppose that string 2 is cut. What is the normal force of the ramp on the bus then?

$N = m_b g \cos\theta = 0.2\ kg\ 9.8\ \frac{m}{s^2} \cos 30° = 1.7\ N$

e. [4 pts] With string 2 cut, what is the acceleration of the bus?

$\Sigma F_x = m a_x = 0$ independent of whether string 2 is there or not.

$\Sigma F_y = m a_y = 0$ also, so $a = 0$

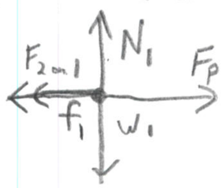
Name (please print): ______________________________

SUID: ____________

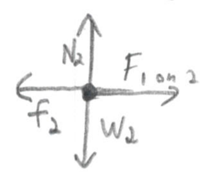
3. [25 pts total] The following diagram shows two wooden blocks attached by a string being pulled by another string along a wooden table. The masses of the blocks are m_1=0.22 kg and m_2=0.15 kg. The person pulling the string is pulling horizontally and exerting a force of 3 N. Friction is not negligible. The coefficient of static friction of wood on wood is 0.50 and the coefficient of kinetic friction of wood-on-wood is 0.20.

a. [4pts] Draw the free body diagram for block one and the free body diagram for block two.

block 1



block 2



$$\Sigma \vec{F} = m\vec{a}$$

b. [8pts] What is the maximum force that can be exerted before the blocks begin to accelerate? Assume blocks are at rest. $f_1 = \mu_s N_1$, $f_2 = \mu_s N_2$

$F_P - F_{2on1} - f_1 = 0$ $\quad |\vec{F}_{1on2}| = |\vec{F}_{2on1}| \Rightarrow F_{2on1} - f_2 = 0$

$N_1 = m_1 g$
$N_2 = m_2 g$
$\Rightarrow F_P - F_{2on1} - \mu_s m_1 g = 0$, $\quad F_{2on1} - \mu_s m_2 g = 0$
$F_{2on1} = \mu_s m_2 g$ ↳

c. [8pts] Is the 3 N force pulling the string attached to the first block enough to accelerate the blocks? Explain. If the blocks are accelerating, what is the value of the acceleration? Yes, the minimum force needed to accelerate the blocks is 1.81 N. $\Sigma \vec{F} = m\vec{a}$, $a_1 = a_2$, $f_1 = \mu_k N_1$, $f_2 = \mu_k N_2$

$F_P - F_{2on1} - f_1 = m_1 a_1$

$F_{2on1} - f_2 = m_2 a_2 = m_2 a_1$ ↳

d. [5pts] What is the tension in the string connecting the blocks?

$T = F_{2on1} = m_2 a_1 + f_2 = m_2 a_1 + \mu_k m_2 g$

$= 0.15\ kg \times 6.15 \frac{m}{s^2} + 0.20 \times 0.15\ kg \times 9.8 \frac{m}{s^2}$

$= 1.22\ N$

3.) b.) cont.) $F_p - F_{2on1} - \mu_s m_1 g = 0,$

$$F_{2on1} = \mu_s m_2 g$$

$$\Rightarrow F_p - \mu_s m_2 g - \mu_s m_1 g = 0$$

$$\Rightarrow F_p = \mu_s g(m_1 + m_2)$$

$$= 0.50 \times 9.8 \frac{m}{s^2}(0.22 + 0.15)kg$$

$$= 1.81 \text{ N}$$

c.) cont.) $F_p - F_{2on1} - f_1 = m_1 a_1$

$$F_{2on1} - f_2 = m_2 a_1$$

$$\Rightarrow F_{2on1} = m_2 a_1 + f_2$$

$$\Rightarrow F_p - (m_2 a_1 + f_2) - f_1 = m_1 a_1$$

$$F_p - m_2 a_1 - f_1 - f_2 = m_1 a_1$$

$$F_p - f_1 - f_2 = (m_1 + m_2) a_1$$

$$F_p - \mu_K m_1 g - \mu_K m_2 g = (m_1 + m_2) a_1$$

$$a_1 = \frac{F_p - \mu_K g(m_1 + m_2)}{m_1 + m_2}$$

$$= \frac{3\text{ N} - 0.20 \times 9.8 \frac{m}{s^2}(0.22 + 0.15)kg}{(0.22 + 0.15)\,kg}$$

$$= 6.15 \frac{m}{s^2}$$

Name (please print): ____________________________________

SUID: ______________

4. [25 pts total] A 65 kg passenger is standing on a scale in an elevator. The elevator undergoes constant acceleration to reach its cruising speed of 9 m/s, and it takes 4 seconds to reach its cruising speed starting from rest.

a. [6 pts] What is the acceleration of the elevator?

$$V_f = V_i + at \Rightarrow a = \frac{V_f - V_i}{t} = \frac{9\frac{m}{s} - 0\frac{m}{s}}{4s} = 2.25\frac{m}{s^2}$$

b. [4 pts] What is the weight (in Newtons) that the scale reads when the elevator is at rest?

$$W = mg = 65\ kg \times 9.8\frac{m}{s^2} = 637\ N$$

c. [5 pts] What weight does the scale read when the elevator is speeding up?

If the accelerator is moving up

$$N = mg + ma = m(g+a) = 65\ kg \times (9.8 + 2.25)\frac{m}{s^2} = 783\ N$$

If the accelerator is moving down

$$N = m(g-a) = 65\ kg \times (9.8 - 2.25)\frac{m}{s^2} = 491\ N$$

d. [5 pts] What weight does the scale read when the elevator reaches cruising speed?

Elevator isn't accelerating, so

$$N = W = mg = 637\ N$$

e. [5 pts] Suppose the elevator cable snaps and the breaks give out, so that the elevator is in free fall. What is the weight that the scale reads then?

Elevator is in free fall, so acceleration is $-g$.

$$N = mg - mg = 0\ N$$