Physics 211 Exam 2

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Your name: _____

Your recitation section: _____

(see next page for a list)

Cow		/25
Truck		/25
Planet		/25
Exam 2 Total		**/75**

1D makeup		/25
2D makeup		/25
Vector makeup		/25

Instructions

- There are three questions worth a total of 75 points, followed by an opportunity to revisit material from Exam 1.
- Anything you do for the Exam 1 question can only help your score on Exam 1; it cannot hurt your grade, and will not affect your score on Exam 2.
- **You must show your reasoning to receive credit**. A numerical answer with no logic shown will be treated as no answer.
- You are encouraged to use both pictures and words to show your reasoning, not just algebra. Show your reasoning as thoroughly as possible for partial credit.
- If you run out of room, leave a note saying "see back page", and continue your work on the blank page at the end.
- Do not attempt to communicate with anyone other than teaching staff during the exam.
- You may use an ordinary scientific or graphing calculator, but not one that will do algebra for you. If you do not have a calculator, leave your answers in symbolic form.
- Other electronic devices (laptops, smartphones, smartwatches) are not allowed during the exam.
- You may use $g = 10\,\mathrm{m/s^2}$ throughout, except where indicated, to minimize arithmetic.

Recitation Schedule

Section	Day / Time	Room	TA
M025	TTh 5:00-5:55	Bowne Hall 105	Chad
M009	TTh 5:00-5:55	Physics B129E	Kelly
M017	TTh 5:00-5:55	Physics 106	Byron
M018	TTh 6:30-7:25	Physics 106	Byron
M010	TTh 6:30-7:25	Physics B129E	Mingwei
M003	WF 8:25-9:20	Physics B129E	Chad
M011	WF 8:25-9:20	Physics 106	Mingwei
M012	WF 9:30-10:25	Physics 106	Trent
M004	WF 9:30-10:25	Physics B129E	Chandler
M020	WF 9:30-10:25	Life Sciences 156	Byron
M005	WF 10:35-11:30	Physics B129E	Aklima
M013	WF 10:35-11:30	Physics 106	Chad
M006	WF 11:40-12:35	Physics B129E	Aklima
M014	WF 11:40-12:35	Physics 106	Manabputra
M022	WF 11:40-12:35	765 Irving 221	Trent
M007	WF 12:45-1:40	Physics B129E	Chandler
M015	WF 12:45-1:40	Physics 106	Manabputra
M023	WF 12:45-1:40	Newhouse 2	Kelly
M016	WF 3:45-4:40	Physics 106	Aklima
M008	WF 3:45-4:40	Physics B129E	Kelly
M024	WF 3:45-4:40	Crouse-Hinds 017	Trent

Question 1

Mucca the Physics Cow is training to be a draft ox, so our coach Kiersten has them practice by using a rope to pull on an old tractor tire lying on the ground. The rope between Mucca's harness and the tire makes an angle θ with the horizontal.

They apply a tension T to the rope. The coefficient of friction between the tire and the ground is μ_k.

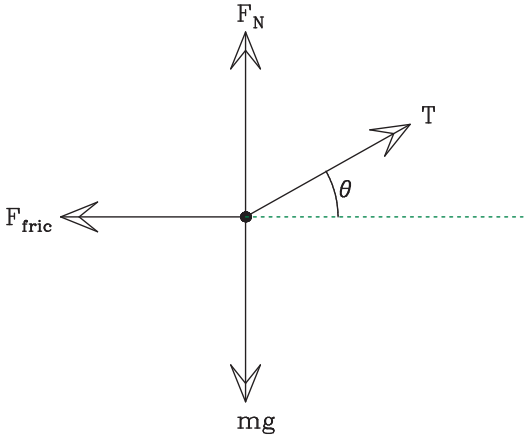
I would like to find the acceleration of the tire.

On the next page, you'll find my solution, but my solution contains an error. On the following page, I will ask you a few questions about my work, and ask you to fix my mistake.

Question 1, continued

Since this problem asks us to connect the forces on the tire to its acceleration, I will use Newton's second law $\vec{F} = m\vec{a}$ and solve for $\vec{a}$.

First I draw a force diagram for the tire. Imagine that the rope is pulling up and to the right. Then friction points to the left. The normal force points upward to stop the tire from falling through the ground, and gravity points downward.



Since the tire moves only in the x-direction, I only need to worry about it. The $x-$component of the tension in the rope is $T\cos\theta$.

Reading Newton's second law off of the force diagram, we have

$$\sum F_x = ma_x$$
$$T\cos\theta - F_{\text{fric}} = ma_x$$

We know that the frictional force is $\mu_k F_N$; since the tire is resting on a flat surface, $F_N = mg$. Putting this in:

$$T\cos\theta - \mu_k mg = ma_x$$

which gives us an acceleration of

$$a = \frac{T\cos\theta - \mu_k mg}{m}$$

Question 1, continued

a) What mistake did I make? You can describe it briefly here, or indicate it clearly on the previous page. *(10 points)*

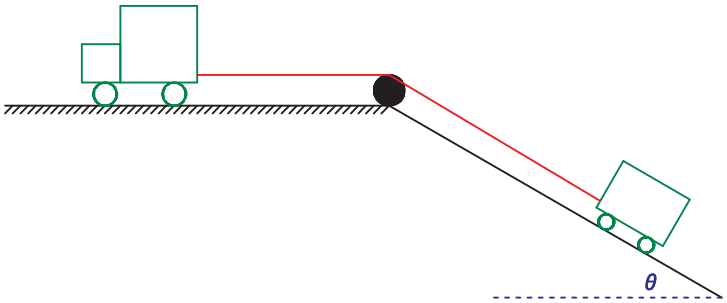
b) What should the answer be instead? Correct my work on the previous page or below, and tell me what the acceleration should be instead. *(15 points)*

Question 2

A truck driver is trying to help out a driver whose car has run off of the side of the road and is stuck on an icy slope. The car that is stuck is on slippery ice, and its driver has shifted it into neutral, so it can roll essentially without friction.

Suppose that:

- The truck has a mass $m_t = 2000$ kg
- The car has a mass $m_c = 1000$ kg
- The icy slope makes an angle $\theta = 30°$ with the horizontal
- The coefficient of static friction between the truck's tires and the pavement is $\mu_s = 0.55$
- The tow cable runs over a mound of snow so that it is parallel to the surface of the ground always (this will make your life easier!)



a) Draw force diagrams for the truck and for the car. *(5 points)*

Question 2, continued

b) Suppose that the truck driver accelerates as rapidly as they can (without spinning their wheels on the snow) to pull the car out. What is that maximum acceleration? *(10 points)*

c) What is the tension in the cable when they are doing this? *(10 points)*

Question 3

The archvillain Dr. Horrible decides that Earth has too many people on it, so he comes up with a mad-science plan to get rid of them: he attaches a machine to Earth's core to gradually increase its rate of rotation to a very high rate. He believes that if he is able to make Earth spin fast enough, this will throw all of the pesky humans into space[1].

After this machine has done its work for a little while, Earth is rotating extremely rapidly. People notice that they feel much lighter, like they are being pushed into space by some "anti-gravity" force; they are worried that if this continues they will fly into space.

a) What force is pushing them into space? If there is no such force, explain why people standing on Earth's surface feel lighter. *(10 points)*

[1] Including his archnemesis, Captain Hammer.

Question 3, continued

b) In order to study the impending $\vec{a}$pocalypse, a person with a mass m standing on the Equator steps on a scale. This scale reads only half as much as it usually does – that is, it reads $\frac{1}{2}mg$, rather than the mg that they expected.

From this, they are able to determine the current angular velocity ω of the Earth. What is the value of ω in terms of the radius of the Earth r and the (pre-apocalypse) value of g? *(10 points)*

c) Dr. Horrible wants to stay on Earth, so he builds his supervillain lair in a spot on Earth that won't be affected very much. Where could he build his lair to be safe, and why would this place be protected from the effect of the rapidly-rotating Earth? *(5 points)*