Name:__________________ ID:_________________ Lab (day/time)____________

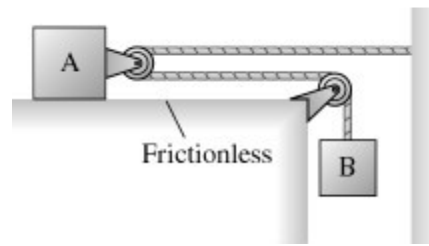
Physics 201

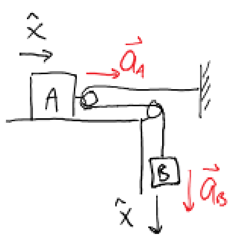
Midterm Exam 2

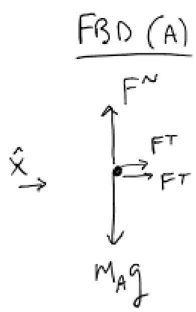
11/9/2017

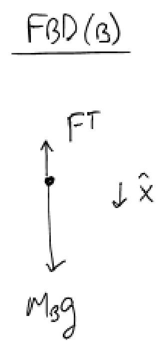
Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating/graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

1. (10 points) Block **A** (3.0 kg) is attached to block **B** (4.0 kg) via a rope and some massless, frictionless pulleys, as shown in the figure. If block **A** starts from rest, how long will it take to slide 1.5 m?









Rubric

- 2pts - FBD's
- 1pt - $\vec{a}$ Constraint
- 2pts - ΣF_x
- 2pts - ΣF_y
- 1pt - finding a_A
- 1.5pts - Kinematics eq.
- 0.5pt - Answer + units

Constraints

$|\vec{a}_B| = 2|\vec{a}_A| \equiv a$

$$\boxed{A} \quad \Sigma F_x \Rightarrow \quad 2F^T = M_A \frac{a}{2}$$

$$\boxed{B} \quad \Sigma F_x \Rightarrow \quad M_B g - F^T = M_B a$$

} 2 eq's, 2 unknowns

$$M_B g - \left(\frac{M_A a}{4}\right) = M_B a$$

$$a = \frac{M_B g}{\left(M_B + \frac{M_A}{4}\right)} = 8.253 \text{ m/s}^2$$

So, $a_A = \frac{a}{2} = 4.126 \text{ m/s}^2$

Now Kinematics

$$\Delta x_A = v_{i,A}^{\,0}\,\Delta t + \frac{1}{2} a_A \Delta t^2$$

$$\Delta t = \sqrt{\frac{2\Delta x}{a_A}} = 0.853 \text{ s}$$

For questions 2 through 4 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **6** correct answers in this section and only the first **6** circled answers will be graded. There is no partial credit.

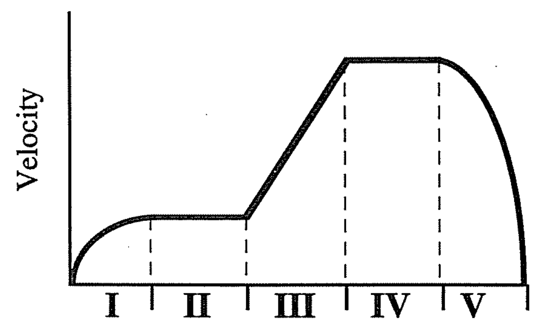
2. A light object moves in the eastward direction at constant speed. A very large net force directed northward acts on the object for 5.0 s. At the end of the 5.0 second period, the net force drops to zero. Which of the following statements are necessarily true?

[F] (a) The object will be moving eastward when the force drops to zero.
[T] (b) The final velocity of the object will be directed north of east.
[T] (c) The change in the velocity of the object will be directed north.
[F] (d) The direction of the acceleration depends on how fast the object was initially moving.
[F] (e) The magnitude of the acceleration depends on how fast the object was initially moving.

3. An astronaut orbits earth in a space capsule whose height above the Earth is equal to the Earth's radius. How does the weight (force of gravity) of the astronaut in the capsule compare to her weight on Earth?

[F] (a) It is equal to her weight on Earth.
[F] (b) It is equal to one-half of her weight on Earth.
[F] (c) It is equal to one-third of her weight on Earth.
[T] (d) It is one-fourth her weight on Earth.
[F] (e) It is equal to one-sixteenth her weight on Earth.

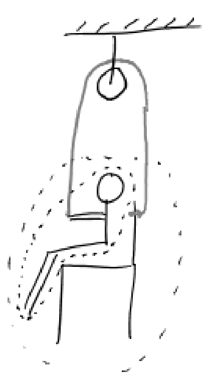
4. The figure shows the velocity as a function of time for an object traveling along a straight line. Which of the following questions regarding this situation are true?



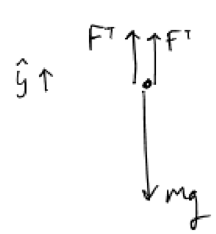
[F] (a) The object is in equilibrium in regions I and V.
[T] (b) The object is in equilibrium in regions II and IV.
[F] (c) The largest constant net force is in region IV.
[T] (d) The largest constant net force is in region III.
[T] (e) The magnitude of the net force is decreasing in region I.
[F] (f) The magnitude of the net force is decreasing in region V.

---

5. (5 points) A man of weight **mg** sits (equilibrium) in a chair of negligible mass that is suspended from a rope. The rope passes over a pulley suspended from the ceiling, and the man holds the other end of the rope in his hands. Neither the man or the chair touch the floor. What is (a) the tension in the rope, and (b) what force does the chair exert on the man? Answer in terms of **mg**.



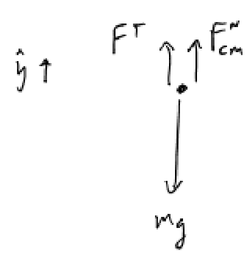
FBD (man + Chair)



$\sum F_y \Rightarrow 2F^T - mg = ma_y = 0$

(a) $F^T = \frac{mg}{2}$

FBD (Man)



$\sum F_y \Rightarrow F^T + F^N_{cm} - mg = ma_y = 0$

(b) $F^N_{cm} = mg - F^T$

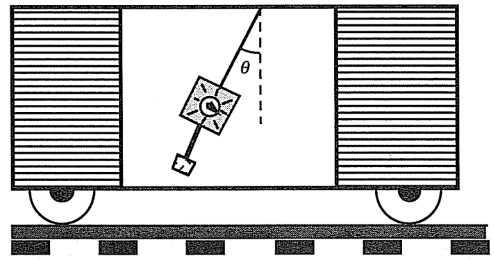
$F^N_{cm} = \frac{mg}{2}$

Rubaic

(a) 2.5 pts

(b) 2.5 pts

6. (10 points) A spring scale, which measures forces, is loosely fastened, (i.e. it can swing back and forth) to the ceiling of a railway car. When a 1.5-kg block is hung from the scale and the car maintains a constant acceleration, the scale reads 18 N and is oriented as shown in the figure. All of the following questions refer to the time while the car is accelerating and the block is maintaining a constant angle with respect to the vertical. (a) Can the direction of the acceleration of the car be determined and if so, which direction is it in? (b) Can the direction of the velocity of the car be determined and if so, which direction is it in? Determine (c) the angle theta and (d) the acceleration of the car?

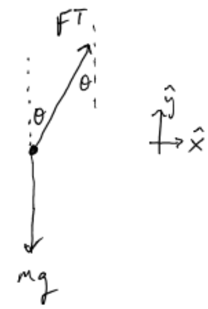


(a) yes, analysis of ΣF (below) shows ΣF is to the right, so accel is to the right

(b) No, could be speeding up to right or slowing down while traveling left.

(c) + (d)

FBD (Block)



(spring scale value)

$$\Sigma F_y \Rightarrow F^T\cos\theta - mg = m a_y^{\,0} \Rightarrow \cos\theta = \frac{mg}{F^T} \Rightarrow \theta = 35.25°$$

$$\Sigma F_x \Rightarrow F^T\sin\theta = m a_x \Rightarrow a_x = \frac{F^T\sin\theta}{m} = 6.93\ m/s^2$$

Rubric

(a) 1.5pts

(b) 1.5 pts

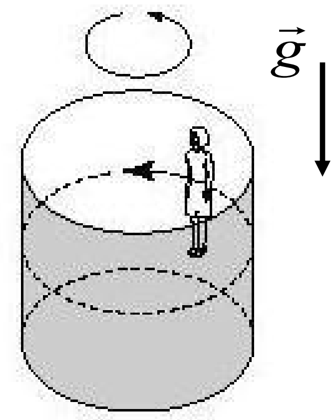
(c)+(d) 2pts - FBD

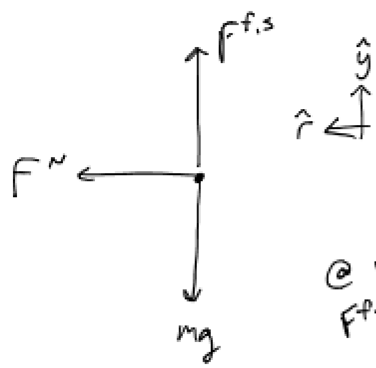
2pts - ΣF_y

2pts - ΣF_x

1pt - θ + a answers + units

7. (10 points) The Gravitron is an amusement park ride that lets riders experience the effect of rotating inside a drum at very high speeds. In the figure you can see the rider is on the inside of the drum that is rotating about its central axis. The rider is pinned to the side of the walls while the drum rotates, making the illusion of a fictitious force pushing them against the side walls. This fictitious force is called the centrifugal force but that is not what this question is about. If the rotational rate is great enough, the floor of the apparatus will drop down and friction alone will keep the rider vertical and not falling towards Earth. If the drum has a radius of 10 m and the coefficient of static friction between the person and the walls of the drum is 0.4, what is the minimum number of revolutions per minute (rpm) to hold the person up without the aid of the floor.





$\Sigma F_r \Rightarrow \quad F^N = m\frac{V^2}{r}$ (a_r)

$\Sigma F_y \Rightarrow \quad F^{f,s} - mg = m a_y^{\,0}$

@ min rev, $F^{f,s} \to F^{f,s,max}$ $\rightarrow$ $\mu_s F^N - mg = 0$

$\mu_s\left(m\frac{V^2}{r}\right) - mg = 0$

$V^2 = \frac{gr}{\mu_s}$

w/ $|\vec{V}| = \frac{\text{dist}}{\text{time}} = \frac{N 2\pi r}{60\,s}$

where $N = \#$ of rev

$\left(\frac{N 2\pi r}{60\,s}\right)^2 = \frac{gr}{\mu_s}$

w/ $r = 10\,m$, $\mu_s = 0.4$, $N = 14.9$ rev

Rubric

1.5 pts - FBD

1.5 pts - ΣF_r

1.5 pts - ΣF_y

1 pt - $a_r = \frac{V^2}{r}$

1 pt - $F^{f,s,max} = \mu_s F^N$

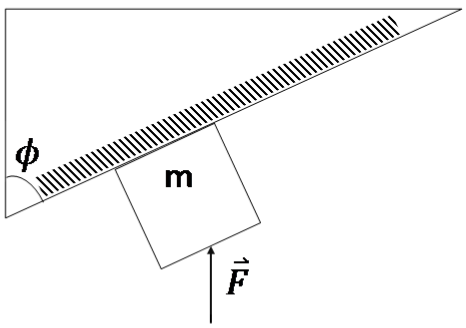
1.5 pts - Combining $\hat{r}$ & $\hat{y}$ via fric & F^N

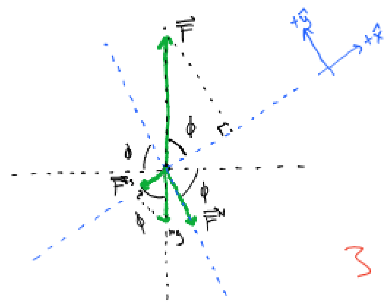
1.5 pts - $|\vec{V}| = \frac{\text{dist}}{\text{Time}}$

0.5 pts - answer

8. (10 points) For parts (a) and (b), draw a complete free body diagram for the following objects indicated in the problem. For each case make sure to scale each vector relative to each other, identify Newton's 3rd law force pairs (if relevant), and indicate which set of axes would be the most advantageous for applying Newton's 2nd law.

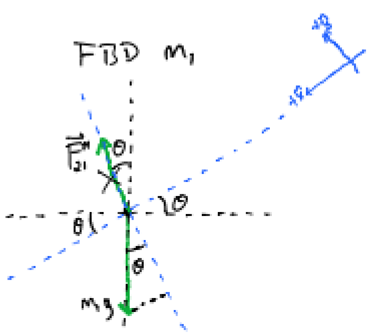
(a) Mass **m** is pushed vertically upward against an incline at a constant speed, as shown in the diagram



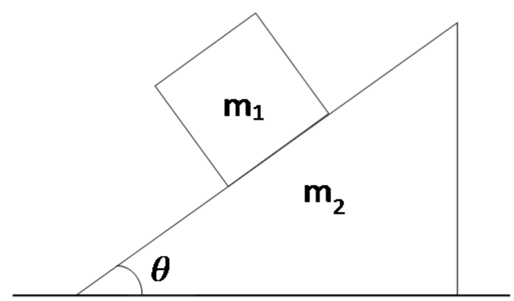


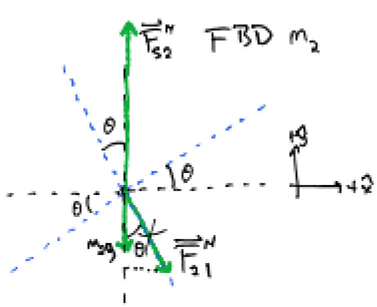
3 pts
+1 4 forces in correct direction
+1 relative scaling
+1 coordinate axes

(b) Mass $\mathbf{m_1}$ is a box which sits atop a frictionless incline of mass $\mathbf{m_2}$ which sits on a frictionless surface. Do the analysis for both masses.



Force Pairs
$|\vec{F}_{21}^{N}| = -|\vec{F}_{12}^{N}|$





6 pts
+5 FBDs
+1 Forces plus directions
+2 relative scaling
+2 coordinate axes
+1 Force pairs

(c) What is the direction of the acceleration of $\mathbf{m_1}$, $\mathbf{m_2}$, and the $\mathbf{m_1 + m_2}$ system?

m_1—down and to the left
m_2—to the right
$m_1 + m_2$ —vector sum of a_1 and a_2

1 pt

extra space if needed

Scores:

Problems

1	2-4	5	6	7	8

Exam Total