Name:______________________________ ID:______________________________

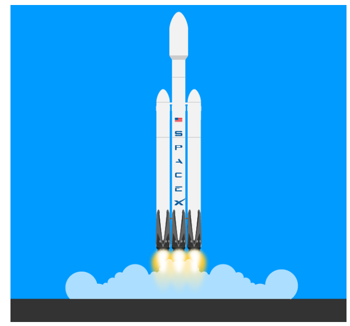
Physics 201

Midterm Exam 2

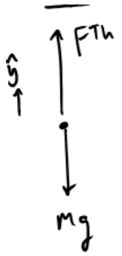
11/7/2018

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. (7 points) A 10,000-kg Space X rocket, with the aid of its thrusters, is able to take off and land vertically. At one instance the rocket is slowing down while it descends towards Earth. (a) If the magnitude of the rocket's acceleration is a ***g***/4, what force is generated by the thrusters? Assume the mass loss of the rocket fuel is negligible and the rocket is near the surface of the Earth. (b) Use the connection between net force and acceleration, and the sense-making technique of checking your sign, to check your answer. Explicitly show how the two are (or are not) self consistent.



FBD.



a) $\sum F_y \Rightarrow \quad F^{Th} - mg = ma_y$

$$F^{Th} = m(a_y + g)$$

$$= mg\left(\tfrac{1}{4} + 1\right) = +122{,}500\ \text{N}$$

b) moving downward + slowing down means acceleration is upward. Net force points in same direction as acceleration so F^{Th} must point upward, in the positive direction

Rubric

(a) +2pt - FBD

+2pt - $\sum F$

+1.5pt - Algebra

+0.5pt - Answer + units

(b) +1 pt - Correct application

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

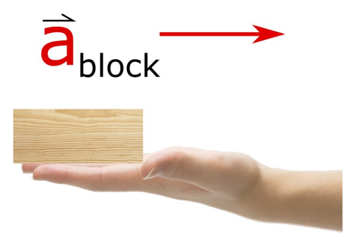
2. An object is moving to the right along a straight line. The net force acting on the object is also directed to the right, but the magnitude of the force is decreasing with time. The object will

[T] (a) continue to move to the right, with its speed increasing with time.
[F] (b) continue to move to the right, with its speed decreasing with time.
[F] (c) continue to move to the right with a constant speed.
[F] (d) stop and then begin moving to the left.

3. You are standing in the back of a moving bus, wearing roller-skates, facing forward. Suddenly the bus comes to a quick stop and you move towards the front of the bus. Which one of the following forces acted on you to cause you to move forward relative to the back of the bus?

[F] (a) The force of gravity.
[F] (b) The normal force from the floor of the bus.
[F] (c) The force of friction between you and the floor of the bus.
[F] (d) The force of inertia.
[T] (e) No forces were acting on you that caused you to move forward relative to the bus.

4. A block is on top of a hand and the block is accelerating towards the right, as shown in the figure. The only forces acting on the block are gravity from the Earth and forces from the hand. Which of the following statements are *necessarily* true regarding this situation?



[F] (a) The force of friction from the hand on the block is in the opposite direction of the block's motion.
[F] (b) The force of friction from the hand on the block is towards the left.
[T] (c) The force of friction from the hand on the block is towards the right.
[F] (d) The block is not sliding relative to the hand.
[T] (e) The force of friction from the block on the hand is towards the left.
[F] (f) The force of friction from the block on the hand is towards the right.

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5. (4 points) Suppose the force of wind resistance is proportional to the speed of the object and in the direction opposite the object's velocity. If you throw an object upward, when is the magnitude of the acceleration the highest, (i) right after the object is released, (ii) at the top of its trajectory, or (iii) it's the same throughout the entire trajectory? Explain your reasoning.

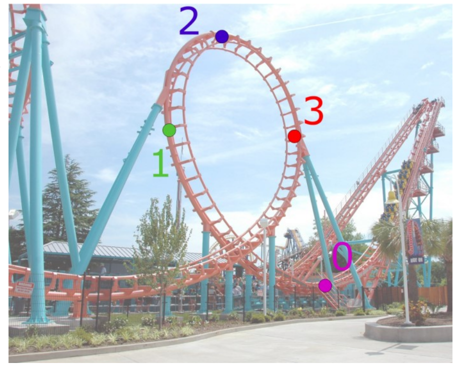
(i) Right after released. That is the point where the drag is the greatest and points in the same direction as gravity, creating the greatest net force and thus acceleration.

Rubric

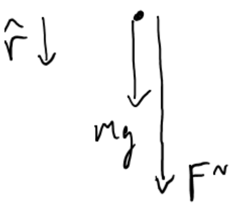
2pt - Answer

2pt - Reasoning

6. (7 points) An amusement park ride is designed to really push you against your seat when you're at the top of a loop-the-loop. The effect is so strong that the normal force pushing on you is twice your weight. (a) How fast in terms of the acceleration of gravity ***g***, and the radius of the loop-the-loop ***r***, must you be going at the top of the loop to achieve this feat? (b) Use the dimensional analysis sense-making technique to check your answer. Explicitly show that the dimensions are (or are not) consistent.



FBD (Top)



(a) $\Sigma F_r \Rightarrow mg + F^N = m a_r$, $F^N = 2mg$, $a_r = m\frac{v^2}{r}$

So, $mg + 2mg = m\frac{v^2}{r}$

$$V = \sqrt{3gr}$$

(b) Dimensional Analysis of ↑

$$\frac{[L]}{[T]} \overset{?}{=} \left[\frac{[L]}{[T]^2}[L]\right]^{1/2}$$

yes the dimensions on LHS match RHS

Rubric

(a) + 1pt - FBD

+ 1.5pt - ΣF

+ 1pt - $F^N = 2mg$

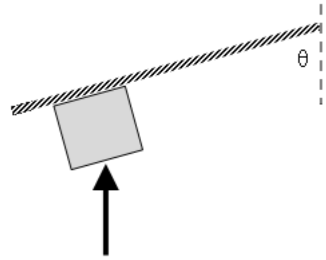
+ 1pt - $a_r = \frac{v^2}{r}$

+ 1pt - Algebra

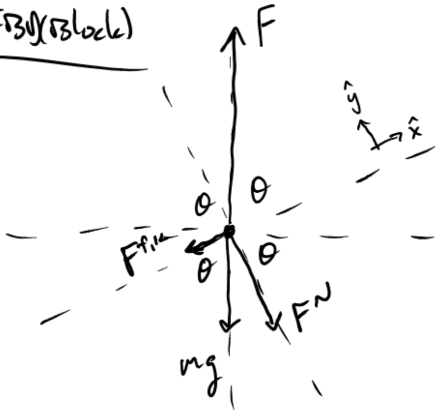
+ 0.5pt - Answer

(b) + 1 pt - Correct Application

7. (10 points) A 2-kg-block is pushed upward from underneath by a constant 50-N vertical force. The block is sliding on the bottom side of an incline plane that makes an angle of 70º with the vertical. The coefficient of kinetic friction between the block and the plane is 0.2. If after traveling a total distance of 4 m the block is traveling at a speed of 4.443 m/s up the incline, what was the initial speed of the block?



FBD (Block)



$$\Sigma F_y \Rightarrow F\sin\theta - mg\sin\theta - F^N = m a_y^{\,0}$$

$$F^N = (F - mg)\sin\theta$$

$$\Sigma F_x \Rightarrow F\cos\theta - mg\cos\theta - \underbrace{\mu_k F^N}_{F^{fik}} = m a_x$$

$$(F-mg)\cos\theta - \mu_k(F-mg)\sin\theta = m a_x$$

$$a_x = \frac{(F-mg)(\cos\theta - \mu_k\sin\theta)}{m}$$

Kinematics

$$V_{fx}^2 = V_{ix}^2 + 2a_x\Delta X$$

$$V_{ix}^2 = V_{fx}^2 - \frac{2\Delta X(F-mg)(\cos\theta - \mu_k\sin\theta)}{m} \Rightarrow V_{ix} = 1.00\ \text{m/s}$$

Rubric

+2pt - FBD

+2pt - ΣF_x

+2pt - ΣF_y

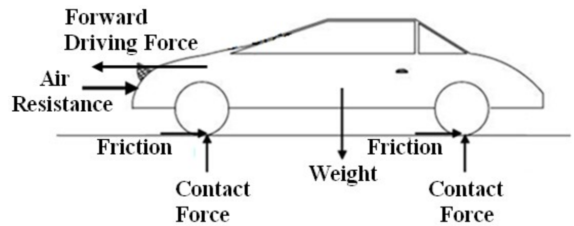
+1pt - $F^{fik} = \mu_k F^N$

+1.5pt - Solving for a

+1pt - Kinematics

+0.5pt - Answer + units

8. (4 points) This diagram was found on a major educational website to explain forces acting on a car speeding up to the left. What are two things in this diagram that are physically incorrect or make no sense?

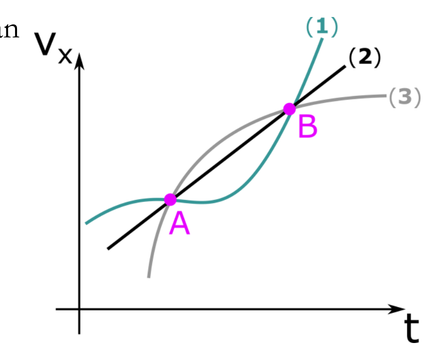


1. I don't know what a Forward Driving Force is, it is not a real force.
2. Friction is in the wrong direction. If the Forward Driving Force is not present, there is nothing to push it forward with friction going against the cars motion. The friction is what propels a car forward.

Rubric

+2 pts each

9. (4 points) The figures shows the velocity as a function of time for an object moving along a straight line. Rank the magnitude of the net force acting on the object at point B. Explain your reasoning.



$$\Sigma F_x = m a_x$$

$$\Sigma F_x = m \frac{\Delta V_x}{\Delta t}, \quad \text{So } \Sigma F_x \propto \text{Slope of } V(t)$$

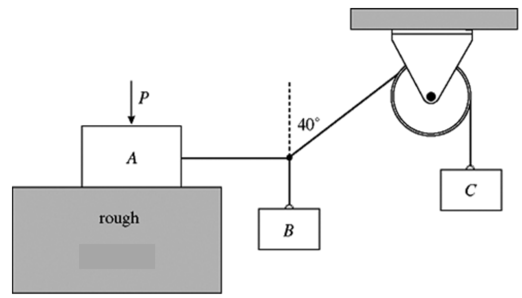
$$|\Sigma F_1| > |\Sigma F_2| > |\Sigma F_3|$$

Rubric

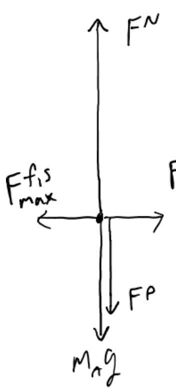
+2 pts - Ranking

+2 pts - Reasoning

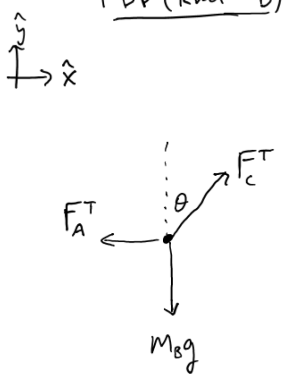
10. (10 points) A system of blocks and a frictionless pulley is shown in the figure. Block **A** has a mass of 2.0 kg and is on a rough horizontal surface. The rope pulls horizontally on block **A**. Block **C** has a mass of 1.0 kg. An external force P = 23.0 N, applied vertically to block **A**, barley maintains the system at rest as shown in the figure. What is the coefficient of static friction between block **A** and the rough surface?



FBD (A)



FBD (knot + B)



FBD (C)

[C] $\sum F_y \Rightarrow F_C^T - M_B g = M_C a_{y_C}^{\nearrow 0} \Rightarrow F_C^T \Rightarrow M_C g$

[B] $\sum F_x \Rightarrow F_C^T \sin\theta - F_A^T = M_B a_{x_B}^{\nearrow 0} \Rightarrow F_A^T = F_C^T \sin\theta$

[A] $\sum F_y \Rightarrow F^N - F^P - M_A g = M_A a_{y_A}^{\nearrow 0} \Rightarrow F^N = F^P + M_A g$

$\sum F_x \Rightarrow F_A^T - F^{f_s}_{max} = M_A a_{x_A}^{\nearrow 0}$

or $F_A^T = \mu_s F^N$

So, $M_c g \sin\theta = \mu_s (F^P + M_A g)$

$$\mu_s = \frac{M_c g \sin\theta}{F^P + M_A g} = \boxed{0.148}$$

Rubric

+ 2pts – FBD (A)
+ 1pt – FBD (knot + B)
+ 0.5pt – FBD (C)
+ 1pt – $F_C^T = M_C g$
+ 1.5pt – $\sum F$ on knot
+ 2pt – $\sum F$, x & y, on A
+ 0.5pt – $F^{f_s}_{max} = \mu_s F^N$
+ 1 pt – Algebra
+ 0.5pt – Answer + (no) units