ABRHS Physics (H) Name: KEY

Test 4: *Newton's Laws II*

2012

Equations and Constants:

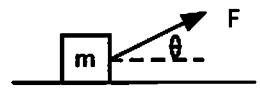
$\bar{v} = \frac{\Delta x}{\Delta t}$ $v = \frac{dx}{dt}$ $\bar{a} = \frac{\Delta v}{\Delta t}$ $a = \frac{dv}{dt}$ $\bar{v} = \frac{1}{2}(v_i + v_f)$ $|g| = 10\text{ m/s}^2$

$x = \frac{1}{2}at^2 + v_i t + x_i$ $v = at + v_i$ $v_f^2 = v_i^2 + 2a\Delta x$ $R = \frac{v^2 \sin 2\theta}{g}$ $a_c = \frac{v^2}{r}$

$\sum \vec{F} = m\vec{a}$ $w = mg$ $w_\perp = mg\cos\theta$ $w_\parallel = mg\sin\theta$ $f = \mu N$

Multiple Choice: *Choose the letter of the best answer. 3 points each.*

1. A A box is being pulled across the floor with a constant speed across a level floor by an applied force F as shown in the diagram. Which of the following must be true?



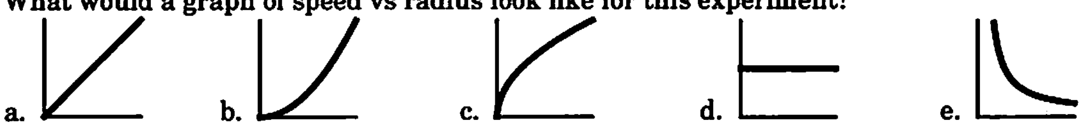
a. The force of friction is less than the applied force F.
b. The normal force is less than the applied force F.
c. There is no friction force.
d. None of those things must be true.

→ Non zero θ!

Questions 2 and 3 refer to the following:
Some grad students do a lab in which a car is driving in circles on a level parking lot. They vary the radius of the circle they are driving in and measure the fastest speed the car can have and still maintain that particular circle.

$a_c = \frac{v^2}{r}$ $v^2 = a_c r$ $(v = \sqrt{a_c r})$

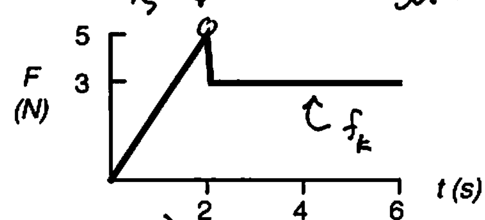
2. C What would a graph of speed vs radius look like for this experiment?



3. D From their data, when the radius of the circle was 25 m, the car had a speed of 13 m/s. What was the coefficient of friction between the tires and the parking lot?
a. 0.15. b. 0.27. c. 0.52. d. 0.68.
e. can't tell because you need the mass of the car.

$\mu mg = \frac{mv^2}{r}$ $\mu = \frac{v^2}{rg} = \frac{(13)^2}{(25)(10)}$

Questions 4 and 5 refer to the following:
A 10 N object is on a level table at rest. It is then pulled with a slowly increasing force. After about 2 seconds, the object suddenly starts to move, and then it is pulled with a slow constant speed for another 4 seconds. The force as a function of time is shown in the diagram to the right.



@ rest $5 = \mu(10)$ $\mu = .5$

4. A What is the coefficient of static friction?
a. 0.5. b. 0.3. c. 0.25. d. 0.2.
e. What the? I didn't pay attention in class!

5. C What is the coefficient of kinetic friction? $3 = \mu(10)$
a. 0.75. b. 0.5. c. 0.3. d. 0.2.
e. Are you kidding me? I didn't read the book either!

6. C A car of mass m has a speed of v and is driving over a hill. The hill can be thought of as the top of a circle of radius r. What is the fastest the car can travel over the hill and stay on the hill?
a. $\sqrt{2rg}$. b. $\sqrt{mg}$. c. $\sqrt{rg}$. d. $\sqrt{rmg}$. e. $\sqrt{2rmg}$

↑N ↓mg but N=0 @ limit so $mg = \frac{mv^2}{r}$ $v^2 = rg$

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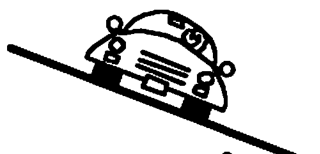
7. B You are pushing a 15 kg chair across the floor with a constant speed and with a force of 100 N. What is the coefficient of friction between the chair and the floor?
a. 0.85. b. 0.67. c. 0.33. d. 0.15.
e. the answer depends on the speed.

$100 = \mu(150)$
$\mu =$

8. E A 20 N box is at rest on the floor. There is a coefficient of static friction of 0.4 between the box and the floor. You then decide to push the box with a horizontal force of 5 N. What is the acceleration of the box?
a. 6.5 m/s². b. 2.5 m/s². c. 1.5 m/s². d. 0.15 m/s². e. 0 m/s².

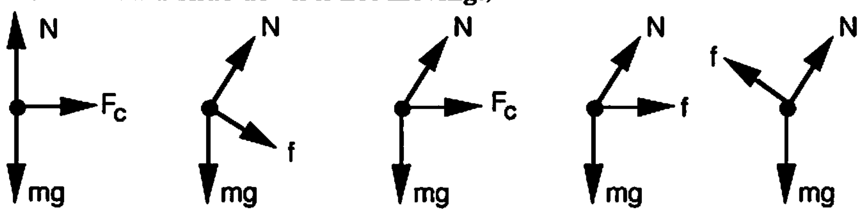
$f_s \le (.4)(20) \le 8N$

key! 5 N is less than max static
∴ no acceleration



θ

9. E A car is speeding around a banked curve, shown above. Which of the following would be the best free-body diagram for the forces acting on the car when it is going *as slow* as it can around the track without sliding down the track? (Assume the track is steep enough that the car would slide down if not moving.)



a. b. c. d. e.

f will help hold it up b/c it will be sliding down

10. A It is usually noticeably more difficult getting a large object at rest to initially move than it is in keeping it sliding along at constant speed. This is because
a. the coefficient of static friction is greater than the coefficient of kinetic friction.
b. you are fighting the inertia of the object to get it going.
c. that is stupid – it is harder to keep it moving than it is to initially get it moving.
d. it is an illusion due to the way we interpret forces when we are rest compared to in when we are in motion.

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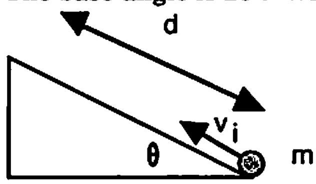
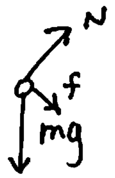
Problem Solving: Show all work, including a correct free-body diagram.

11. An object is launched up an inclined plane with an initial speed of 7 m/s. The coefficient of friction between the object and the plane is 0.4 and it travels a distance d up the inclined plane. The base angle is 25°. What is d?





~~$v_f^2 = v_i^2 + 2a\Delta x$~~

~~$0 = (7)^2 + 2a($~~

$\Sigma F_{\parallel} = ma$ $\qquad$ $\Sigma F_{\perp} = 0$

$f + mg\sin\theta = ma$ $\qquad$ $N - mg\cos\theta = 0$

$\therefore \mu mg\cos\theta + mg\sin\theta = ma$

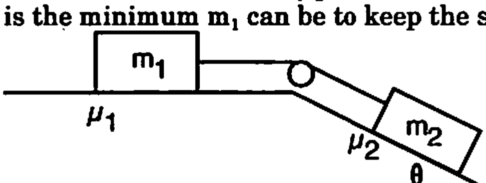
$a = (.4)(10)(\cos 25) + (10)(\sin 25)$

$a = 7.85\ m/s^2$ (down hill)

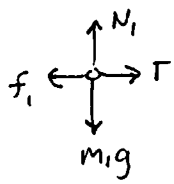
$\therefore v_f^2 = v_i^2 + 2a\Delta x$

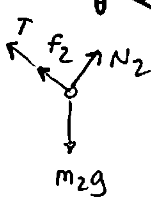
$0 = (7)^2 + 2(-7.85)d$ → $d = 3.12\,m$

12. Two masses are attached through a string and a pulley as shown in the diagram. There is a coefficient of friction of μ_1 between the first mass and the horizontal table it is on. There is a coefficient of friction of μ_2 between the second mass and the inclined plane of base angle ø. What is the minimum m_1 can be to keep the system at rest?



~~$\Sigma F_{\parallel} = 0$~~ $\qquad$ $\Sigma \vec{F} = 0$





$\Sigma F_{\parallel} = 0$ $\qquad$ $\Sigma F_{\perp} = 0$

$T + f_2 - m_2g\sin\theta = 0$ $\qquad$ $N_2 - m_2g\cos\theta = 0$

$f_1 = \mu_1 N_1$ $\qquad$ $f_2 = \mu_2 N_2$ → $T = m_2g\sin\theta - \mu_2 m_2 g\cos\theta$

$\Sigma F_x = 0$ $\qquad$ $\Sigma F_y = 0$

$T - f_1 = 0$ $\qquad$ $N_1 - m_1g = 0$

$T = \mu_1 m_1 g$

so

$\mu_1 m_1 g = m_2 g\sin\theta - \mu_2 m_2 g\cos\theta$

$$m_1 = \frac{m_2 g(\sin\theta - \mu_2\cos\theta)}{\mu_1 g}$$

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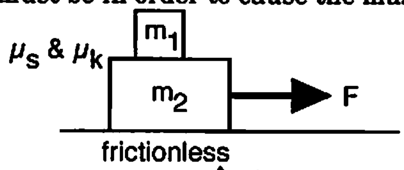
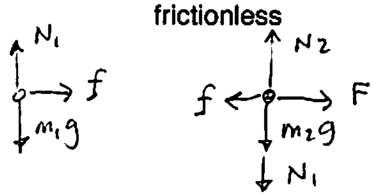
13. A small mass is on top of a larger mass that is on a horizontal frictionless table. The bottom mass is pulled with a force of F, directed horizontally. There is a coefficient of static friction of μ_s and a coefficient of kinetic friction of μ_k between the two masses. What is the minimum F must be in order to cause the masses to separate?



↳ so max static friction

$\Sigma F_x = ma$ $\Sigma F_y = 0$ (both same acceleration)



$f = m_1 a$ $N_1 - m_1 g = 0$

$F - f = m_2 a$ $N_2 - m_2 g - N_1 = 0$

$\therefore F = (m_1 + m_2)a$

$f = \mu_s m_1 g$ ⟶ so $\mu_s m_1 g = m_1 a$

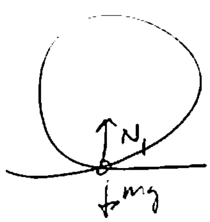
$a = \mu_s g$

$\therefore$ $F = (m_1 + m_2)\mu_s g$

14. A motorcycle has a mass of 250 kg and is doing a loop-the-loop of radius 15 m. It has a constant speed that is double the minimum speed needed for the motorcycle to just barely make the loop. What is the normal force on the motorcycle when it is at the bottom of the loop?

@ bottom

$\Sigma F = \frac{mv^2}{r}$



$N_1 - mg = \frac{mv^2}{r}$

$N_1 = mg + \frac{mv^2}{r} = mg + \frac{m(2\sqrt{rg})^2}{r}$

$= mg + \frac{m4rg}{r} = 5mg$

Find V: @ top N, mg

$\Sigma F = \frac{mv^2}{r}$

$N + mg = \frac{mv^2}{r}$

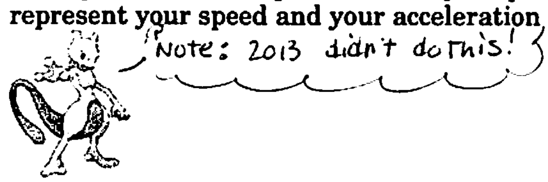
N = 0 @ min v

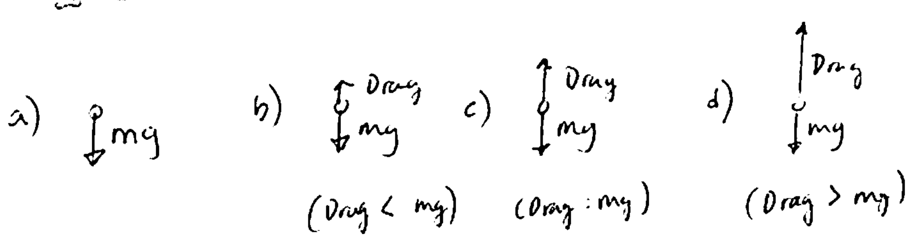
so $mg = \frac{mv^2}{r}$

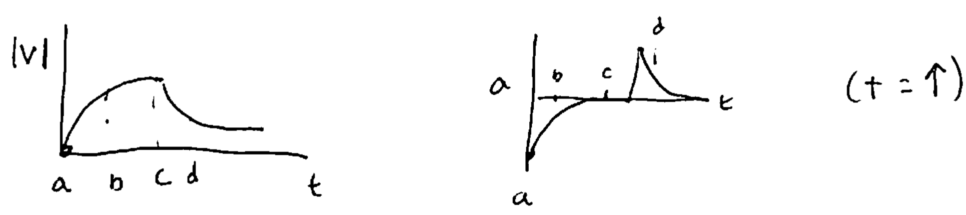
$v^2 = rg$ (min v)

$v_{min} = \sqrt{rg}$

15. Imagine that you dive off a cliff that is 2 miles high. You start with an initial speed of 0 m/s, reach a terminal speed of 50 m/s after about 30 seconds, fall for another 30 seconds, then pull your chute and fall for another minutes or so at about 5 m/s before landing. Draw appropriate free-body diagrams for the following times of your fall: a) initial jump b) after a few seconds c) during the terminal speed d) when your parachute comes out. Also, sketch graphs that would represent your speed and your acceleration while you were in the air.







v. a