PHY 131 Fall 2018

Test #4: Forces

(100 points) Name________________________________

$$x = \frac{1}{2}at^2 + v_i t \qquad x = v_{avg}t \qquad v_f^2 = v_i^2 + 2ax \qquad v_f = v_i + at$$

$$F_{net} = ma \qquad F_F = \mu F_N$$

1609 meters = 1 mile   5280 feet = 1 mile   3.28 feet = 1 meter   *g = -10 m/s² = -32 ft/s².*

Ignore friction and air resistance unless otherwise directed.

SHOW YOUR WORK and PUT YOUR ANSWER IN THE BOX!

1. (20 points) A 70-kg man stands on a scale in an elevator that is moving upward at a speed of 2.5 m/sec and slowing down at a rate of 5 m/sec each second. What is the reading on the scale? Express your answer in units of Newtons.

The force of gravity on the dude is 700 N downward.

The force of the scale on the dude is upward.

Since the dude is moving up and slowing down, he is accelerating downward. The gravitational force is larger than the force from the scale.

$$F_{grav} - F_{scale} = ma = (70\text{ kg})\left(5\frac{\text{m}}{\text{sec}^2}\right) = 350\ N$$

substituting in for F_{grav}

$$700\ N - F_{scale} = 350\ N$$

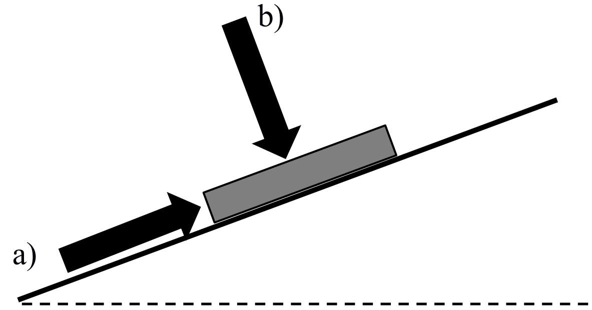
$$F_{scale} = 350\ N$$

and this is what the scale reads.

$$\boldsymbol{F_{scale} = 350\ N}$$

2. (40 points) A 5.0-kg book is sliding at a velocity of 2.0 m/sec down a surface that is inclined at 25 degrees above the horizontal. The coefficient of kinetic friction between the book and the table is 0.40. What applied force is needed to stop the book in 1.0 second if aligned

a) Along the plane (see figure)?
b) Perpendicular to the surface (see figure)?



To stop the book in one second when it is moving a 2 m/sec requires an acceleration of -2 m/sec each second. Since the book has a mass of 5 kg, this requires a net force of

$$F_{net} = ma = (5\text{ kg})\left(2\frac{\text{m}}{\text{sec}^2}\right) = 10\text{ N up the plane.}$$

The gravitational force down the plane is

$$mg\sin 25° = (5\text{ kg})\left(10\frac{\text{m}}{\text{sec}^2}\right)\sin 25° = 21.13\ N$$

The friction force up the plane is

$$\mu_k F_N = \mu_k mg\cos 25° = (0.4)(5\text{ kg})\left(10\frac{\text{m}}{\text{sec}^2}\right)\cos 25° = 18.13\ N$$

The required force is

$$F_{net} = 10\text{ N up the plane} = F_{app} + 18.13 + -21.13\ N$$

$$F_{app} = 13\ N$$

b) The acceleration and required force is the same as in part a. So, to stop the book in one second, we need a net force of 10 N up the plane. This must all come from the frictional force.

$$\mu_k F_N = 0.4\left(F_{app} + mg\cos 25°\right)$$

$$F_{net} = 10\text{ N up the plane} = 0.4\left(F_{app} + mg\cos 25°\right) - 21.13\ N$$

Doing the algebra…

$$\frac{31.13\text{ N}}{0.4} - 45.32\ N = F_{app} = 32.5\ N$$

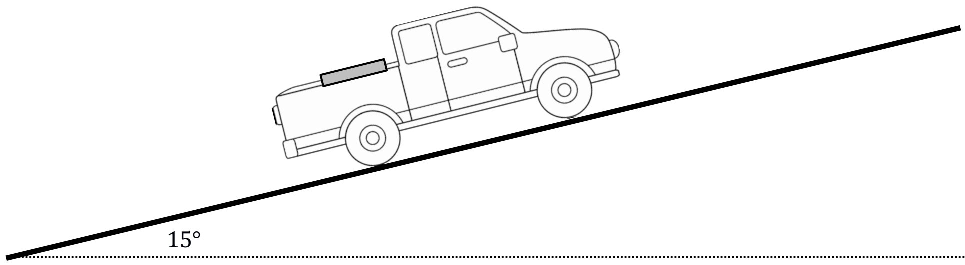
a) **13 N**

b) **32.5 N**

3. (40 points) Mason is hauling a 100 kg stove in the bed of his pick-up. He is stopped at a light on a hillside inclined at 15 degrees above the horizontal, as shown. The coefficient of static friction between the stove and the bed of the pick-up is 0.65, and the coefficient of kinetic friction between the stove and the bed of the pick-up is 0.50.

a) Once the light turns, how quickly can he reach a driving speed of 20 m/s without the stove sliding along the bed of the truck? Give your answer for time in seconds.

b) Let's say Mason is impatient and accelerates at 1.25 times that rate. What is the speed of the stove after sliding 0.50 meters in the bed of the truck?



a) The maximum force that the static coefficient of friction can produce on the stove is:

$$F_{fr,s} = \mu_s F_N = \mu_s mg\cos 15° = (0.65)(100\text{ kg})\left(10\frac{\text{m}}{\text{sec}^2}\right)\cos 15° = 627.9\ N$$

Therefore, the maximum net force up the road that the stove can experience is

$$F_{max,x} = 627.9\ N - mg\sin 15° = 627.9\ N - 1000\ N\sin 15° = 627.9\ N - 258.8\ N$$

which is 369 N. We calculate the maximum acceleration equal to be

$$369\text{ N} = 100\text{ kg}\ a_{max}$$

$$a_{max} = 3.69\text{ m/sec}^2$$

At this acceleration, it will take $\frac{20\frac{m}{sec}}{3.69\frac{\text{m}}{\text{sec}^2}} = 5.42$ seconds

b) Once it slips, then the kinetic coefficient must be used.

The net force in the x direction (along the road) is

$$\mu_k mg\cos 15° - mg\sin 15° = 483.0\ N - 258.8\ N = 224\ N$$

This produces an acceleration of 2.24 m/sec^2. Now we have to calculate the speed after traveling a half meter.

$$v_f^2 = v_i^2 + 2ax$$

$$v_f^2 = 0 + 2\left(2.24\frac{\text{m}}{\text{sec}^2}\right)(0.5\text{ m})$$

So, $v_f = 1.5$ m/sec

a) 5.42 seconds
b) 1.5 m/sec