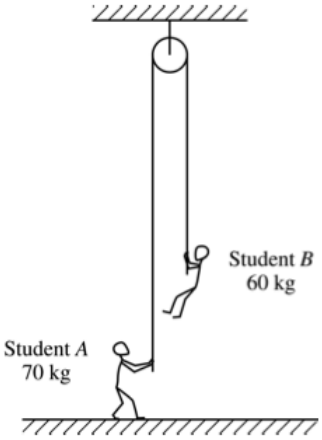
# Dynamics Exam Review

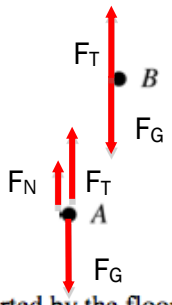
**Directions** – Complete the following problems to help prepare you for the upcoming test.

## 2003 AP® PHYSICS B FREE-RESPONSE QUESTIONS




1. (15 points)
A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling, as shown above. One end of the rope is held by Student *A* of mass 70 kg, who is at rest on the floor. The opposite end of the rope is held by Student *B* of mass 60 kg, who is suspended at rest above the floor.

(a) On the dots below that represent the students, draw and label free-body diagrams showing the forces on Student *A* and on Student *B*.




(b) Calculate the magnitude of the force exerted by the floor on Student *A*.

$\sum F_B = F_T + -F_g = 0$ N

$F_T = F_g = mg = (60\text{ kg})(9.8\text{ m/s}^2) = 588$ N

$\sum F_A = F_T + F_N + -F_g = 0$ N

$F_N = F_g - F_T = mg - F_T$

$F_N = (70\text{ kg})(9.8\text{ m/s}^2) - 588\text{ N} = \boxed{98\text{ N}}$

Student *B* now climbs up the rope at a constant acceleration of 0.25 m/s$^2$ with respect to the floor.

(c) Calculate the tension in the rope while Student *B* is accelerating.

$\sum F_B = F_T + -F_g = m_B a$

$F_T = F_g + m_B a = (60\text{ kg})(9.8\text{ m/s}^2) + (60\text{ kg})(.25\text{ m/s}^2)$

$F_T = 603$ N

(d) As Student *B* is accelerating, is Student *A* pulled upward off the floor? Justify your answer.

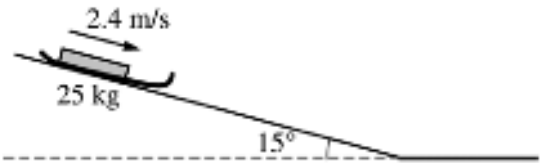
No, since the upward tension in the rope is less than student A's weight of 686 N.

(e) With what minimum acceleration must Student *B* climb up the rope to lift Student *A* upward off the floor?

$\sum F_B = F_T + -F_g = m_B a$

$$a = \frac{F_T + -F_g}{m} = \frac{F_T}{m} - g = \frac{686\text{ N} - 588\text{ N}}{60\text{ kg}} = 1.63\text{ m/s}^2$$

# 2007 AP® PHYSICS B FREE-RESPONSE QUESTIONS



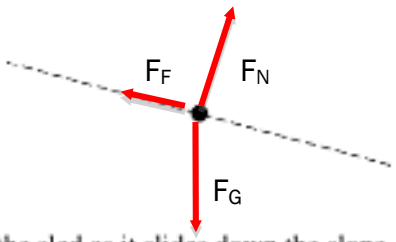

1. (15 points)

An empty sled of mass 25 kg slides down a muddy hill with a constant speed of 2.4 m/s. The slope of the hill is inclined at an angle of 15° with the horizontal as shown in the figure above.

(a) Calculate the time it takes the sled to go 21 m down the slope.

$$t = \frac{x}{v} = \frac{21\text{ m}}{2.4\text{ m/s}} = 8.75\text{ s}$$

(b) On the dot below that represents the sled, draw and label a free-body diagram for the sled as it slides down the slope.




(c) Calculate the frictional force on the sled as it slides down the slope.

$\sum F = 0$ N

$F_f + -Fg_{||} = 0$N

$F_f = mg\sin\theta = (25\text{ kg})(9.8\text{ m/s}^2)(\sin 15°) = 63.4$ N

(d) Calculate the coefficient of friction between the sled and the muddy surface of the slope.

$F_f = \mu F_N$

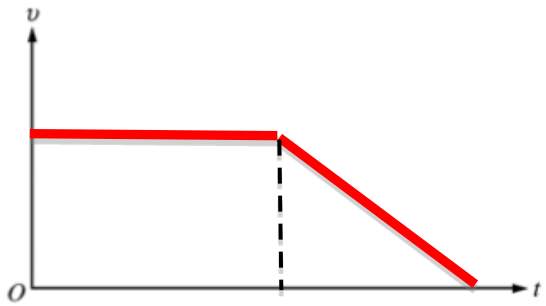
$$\mu = \frac{Ff}{mg\cos\theta} = \frac{mg\sin\theta}{mg\cos\theta} = \tan\theta = \frac{63.4\text{ N}}{(25\text{ kg})(9.8\text{ m/s}^2)(\cos 15°)} = .27$$

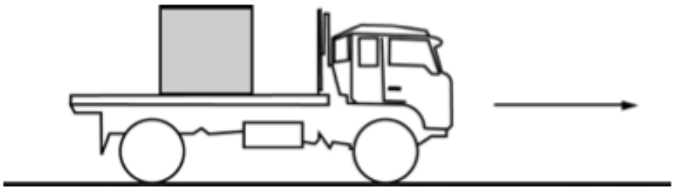
(e) The sled reaches the bottom of the slope and continues on the horizontal ground. Assume the same coefficient of friction.

i. In terms of velocity and acceleration, describe the motion of the sled as it travels on the horizontal ground.

The velocity of the sled with decrease and the acceleration will remain constant.

ii. On the axes below, sketch a graph of speed $v$ versus time $t$ for the sled. Include both the sled's travel down the slope and across the horizontal ground. Clearly indicate with the symbol $t_\ell$ the time at which the sled leaves the slope.





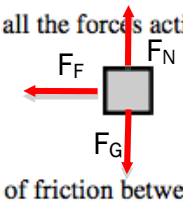
2. (15 points)

A 4700 kg truck carrying a 900 kg crate is traveling at 25 m/s to the right along a straight, level highway, as shown above. The truck driver then applies the brakes, and as it slows down, the truck travels 55 m in the next 3.0 s. The crate does not slide on the back of the truck.

(a) Calculate the magnitude of the acceleration of the truck, assuming it is constant.

$x = x_0 + v_0 t + 1/2at^2$ $\quad a = \frac{2\left[(x - x_0) - v_0 t\right]}{t^2} = \frac{2\left[(55\text{ m}) - (25\text{ m/s})(3.0\text{ s})\right]}{(3.0\text{ s})^2} = -4.4\text{ m/s}^2$

(b) On the diagram below, draw and label all the forces acting on the crate during braking.




(c)

i. Calculate the minimum coefficient of friction between the crate and truck that prevents the crate from sliding.

$\Sigma F = F_{fric} = ma$

$F_{fric} = \mu N = \mu mg$

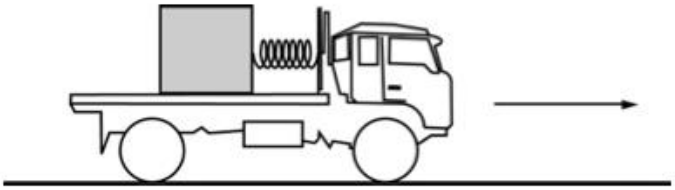
$\mu mg = ma$

$\mu = \frac{a}{g} = \frac{4.4\text{ m/s}^2}{9.8\text{ m/s}^2} = 0.45$

ii. Indicate whether this friction is static or kinetic.

X Static ____Kinetic

Now assume the bed of the truck is frictionless, but there is a spring of spring constant 9200 N/m attaching the crate to the truck, as shown below. The truck is initially at rest.



(d) If the truck and crate have the same acceleration, calculate the extension of the spring as the truck accelerates from rest to 25 m/s in 10 s.

$v = v_0 + at$

$a_x = \frac{v_x - v_{0x}}{t} = \frac{25\text{ m/s} - 0\text{ m/s}}{10\text{ s}} = 2.5\text{ m/s}^2$

$F = ma = kx$

$x = \frac{ma}{k} = \frac{(900\text{ kg})(2.5\text{ m/s}^2)}{9200\text{ N/m}} = 0.24\text{ m}$

(e) At some later time, the truck is moving at a constant speed of 25 m/s and the crate is in equilibrium. Indicate whether the extension of the spring is greater than, less than, or the same as in part (d) when the truck was accelerating.

___ Greater X Less ___ The same

Explain your reasoning.

When the truck is moving at a constant speed, the crate is also moving at the same constant speed with zero acceleration. This means the net force on the crate must be zero; since the bed of the truck is frictionless, the force of the spring on the crate must also zero, and so the spring is not extended at all.