CSD2301 Practice Solutions

5. Application of Newton's Laws Part 1

LIN QINJIE

Practice Question 1

For a human body falling through air in a spread-eagle position, the numerical value of the Constant D is about 0.25 kg/m. Using the simple equation from *Young* & *Freedman*, find the terminal speed for an 80 kg skydiver.

$$\boxed{v_t = \sqrt{\frac{mg}{D}}}$$

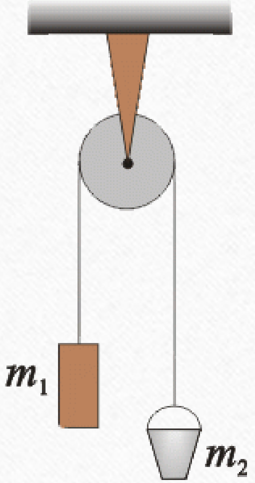
$$= \sqrt{(\frac{80 \times 9.8}{0.25}}$$

$$= 56 \text{ m/s}$$

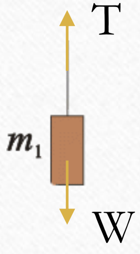
Practice Question 2

Two 25.0 N weights are suspended at opposite ends of a rope that passes over a light, frictionless pulley. The pulley is attached to a chain that goes to the ceiling. a) What is the tension in the rope? b) What is the tension in the chain?

a) The tension in the rope must be equal to each suspended weight, 25.0 N. b) If the mass of the light pulley may be neglected, the net force on the pulley is the vector sum of the tension in the chain and the tensions in the two parts of the rope; for the pulley to be in equilibrium, the tension in the chain is twice the tension in the rope, or 50.0 N.

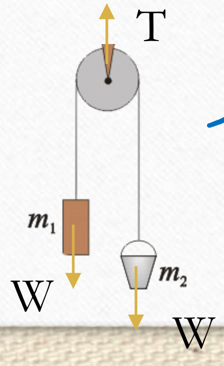


a)



$T = W$
$= 25 N$

b)

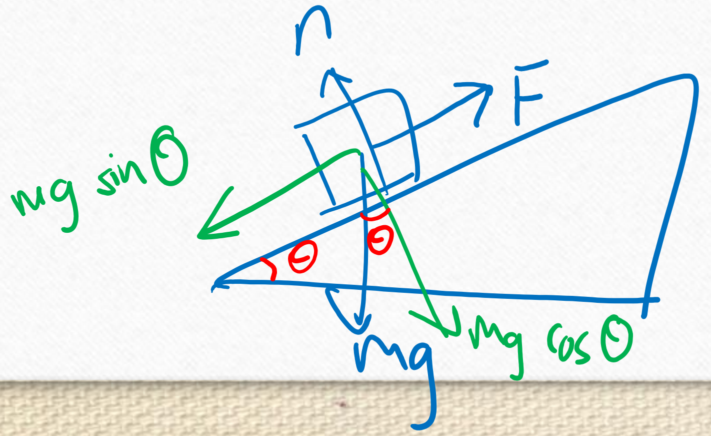


$T = 2W$
$= 2(25)$
$= 50 N$

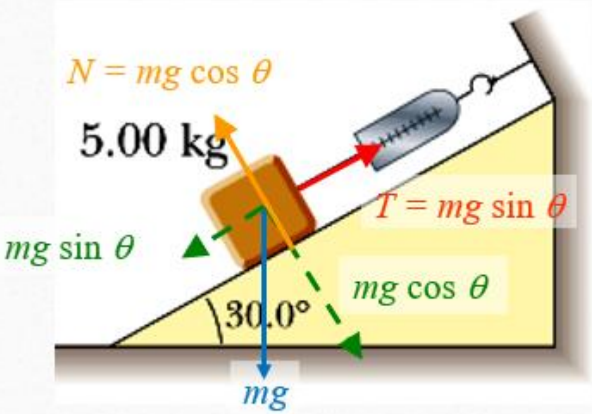
Practice Question 3

A street at Holland Drive makes an angle of 17.5° with the horizontal. What force parallel to the street surface is required to keep a truck of loaded mass 1390 kg from rolling down the street?

$$F = mg\sin\theta = (1390)(9.8)\sin 17.5° = 4096\ N$$



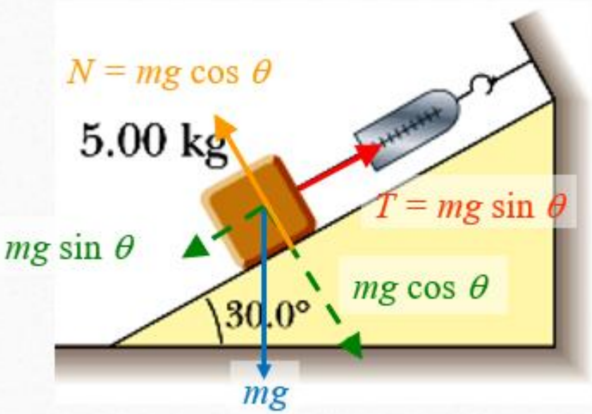
Hint: Rmb this example in Chap 4?



Practice Question 4

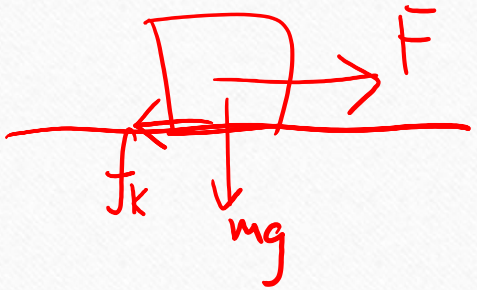
A man pushes on a piano with a mass 180 kg so that it slides at constant velocity down a ramp that is inclined at 11° above the horizontal. Neglect friction acting on the piano. If the force applied by the man is parallel to the incline, calculate the magnitude of this force.

Hint: Rmb this example in Chap 4?



The magnitude of the force must be equal to the component of the weight along the incline, or $W\sin\theta = (180\,\text{kg})(9.80\,\text{m/s}^2)\sin 11.0° = 337$ N.

Practice Question 5

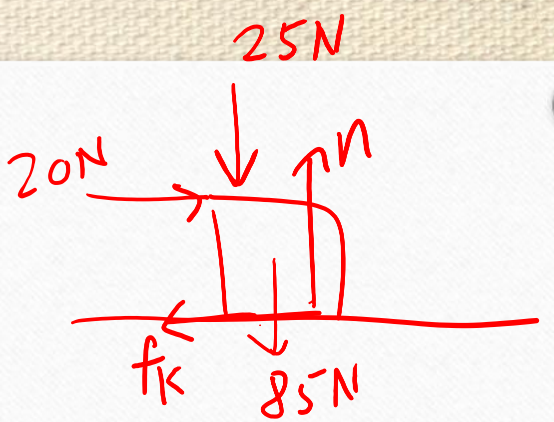


A worker pushes a box with mass 11.2 kg on a horizontal surface with a constant speed of 3.50 m/s. The coefficient of kinetic friction between the box and the surface is 0.20. a) What horizontal force must the worker apply to maintain the motion? b) If the force calculated in part (a) is removed, how far does the box slide before coming to rest?

a) For the net force to be zero, the applied force is

$$F = f_{\mathrm{k}} = \mu_{\mathrm{k}} n = \mu_{\mathrm{k}} mg = (0.20)\,(11.2\ \mathrm{kg})\,(9.80\ \mathrm{m/s^2}) = 22.0\ \ \mathrm{N}.$$

b) Acceleration is $\mu_k g$ in the opposite direction. Using $v^2 = u^2 + 2as$, we get $u^2 = 2as$.
Hence, s = 3.13 m



Practice Question 6

= mg

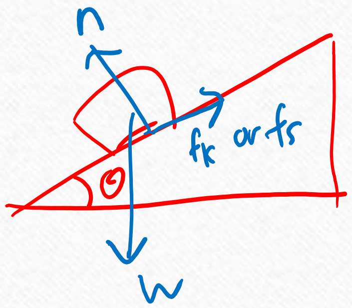
An 85 N box of oranges is being pushed across a horizontal floor. As it moves, it is slowing at a constant rate of 0.90 m/s each second. The push force has a horizontal component of 20 N and a vertical component of 25 N downward. Calculate the coefficient of kinetic friction between the box and the floor.

The coefficient of kinetic friction is the ratio $\frac{f_{\mathrm{k}}}{n}$, and the normal force has magnitude $85\,\mathrm{N} + 25\,\mathrm{N} = 110\ \mathrm{N}$. The friction force, from $F_{\mathrm{H}} - f_k = ma = w\frac{a}{g}$ is

$$f_{\mathrm{k}} = F_{\mathrm{H}} - w\frac{a}{g} = 20\,\mathrm{N} - 85\,\mathrm{N}\left(\frac{-0.9\,\mathrm{m/s^2}}{9.80\,\mathrm{m/s^2}}\right) = 28\ \mathrm{N}$$

(note that the acceleration is negative), and so $\mu_{\mathrm{k}} = \frac{28\,\mathrm{N}}{110\,\mathrm{N}} = 0.25$.

Practice Question 7



A 25 kg box of textbooks rests on a loading ramp that makes an angle θ with the horizontal. The coefficient of kinetic friction is 0.25 and the coefficient of static friction is 0.35. a) As the angle α is increased, find the minimum angle at which the box starts to slip. b) At this angle, find the acceleration once the box has begun to move. c) At this angle, how fast will the box be moving after it has slid 5.0 m along the loading ramp.

a) The normal force will be $w\cos\theta$ and the component of the gravitational force along the ramp is $w\sin\theta$. The box begins to slip when $w\sin\theta > \mu_s w\cos\theta$, or $\tan\theta > \mu_s = 0.35$, so slipping occurs at $\theta = \arctan(0.35) = 19.3°$, or 19° to two figures.

$\mu_k n$

b) When moving, the friction force along the ramp is $\mu_k w\cos\theta$, the component of the gravitational force along the ramp is $w\sin\theta$, so the acceleration is

$$(w\sin\theta) - w\mu_k\cos\theta)/m = g(\sin\theta - \mu_k\cos\theta) = 0.92\ \mathrm{m/s^2}.$$

(c) $2ax = v^2$, so $v = (2ax)^{1/2}$, or $v = [(2)(0.92\ \mathrm{m/s^2})(5\ \mathrm{m})]^{1/2} = 3\ \mathrm{m}.$ ← Should be m/s

Practice Question 8

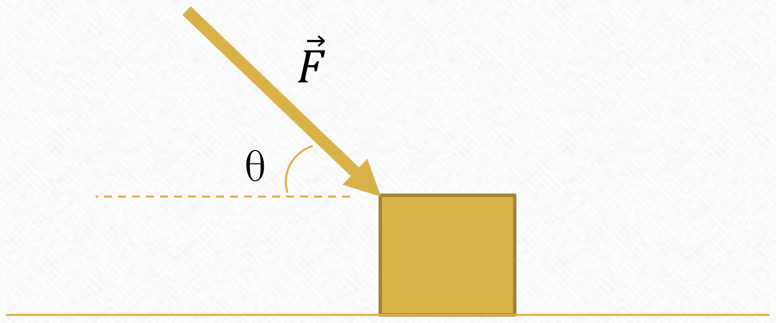
A large crate with mass m rests on a horizontal floor. The coefficient of kinetic friction between the crate and the floor is μ_k. A woman pushes downward at an angle θ below the horizontal on the crate with a force $\vec{F}$. What magnitude of force $\vec{F}$ is required to keep the crate moving at constant velocity?

The magnitude of the normal force is $mg + |\vec{\boldsymbol{F}}| \sin\theta$. The horizontal component of $\vec{\boldsymbol{F}}$, $|\vec{\boldsymbol{F}}|\cos\theta$ must balance the frictional force, so

$$|\vec{\boldsymbol{F}}|\cos\theta = \mu_k(mg + |\vec{\boldsymbol{F}}|\sin\theta);$$

solving for $|\vec{\boldsymbol{F}}|$ gives

$$|\vec{\boldsymbol{F}}| = \frac{\mu_k mg}{\cos\theta - \mu_k \sin\theta}$$



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