Calculating Work

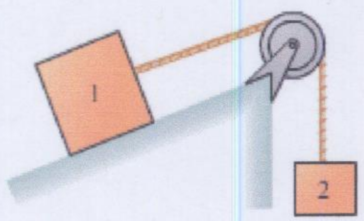
Write the equation which will give the work done by any one force as an object moves:

For the problems below:

1. Sketch the situation and draw all the forces acting on your object of interest.
2. Note on your sketch the direction of motion.
3. Identify the angle θ for each force. If necessary, make a separate picture showing that line of force, the displacement d, and the angle θ.
4. You need to know the magnitude of each force. If necessary, use net F = ma to find any magnitudes you do not know. You do not know in advance whether the object is accelerating! So pick your axes such that one axis is in a direction that you are absolutely <u>certain</u> the object does not accelerate in. Only sum forces along this direction.

a. A sled (mass= 20 kg) is pulled along level ground by a pulling force of 44 N. This pull is directed 35^0 above the horizontal, and the coefficient of kinetic friction is 0.15. Find the work done by each force which acts on the sled if it is moved forward 5.0 m.

b. Box 1 is being pulled up along the ramp by box 2, as shown. Friction is present between box 1 and the ramp. Draw and label all the forces acting on box 1. State whether the work done by each force is positive, negative, or zero. Do the same for box 2.

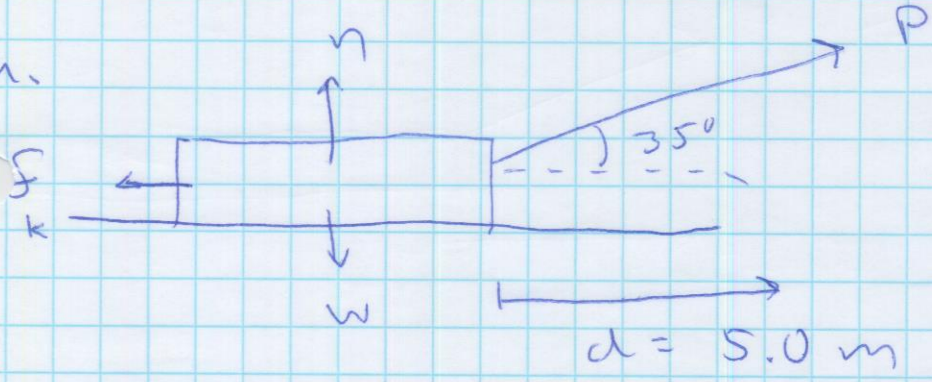


c. A car moving along a level road hits the brakes and skids 45 m before stopping. The coefficient of kinetic friction is 0.35 and the mass of the car is 750 kg. Calculate the work done by each force acting on the car.

d. A crate with a mass of 4.0 kg slides down a ramp angled at 50^0 above the horizontal. The coefficients of kinetic and static friction along the ramp are 0.27 and 0.41, respectively. Calculate the work done by each force acting on the crate as it slides 3.0 m.

e. A physics student swings a tennis ball on a string at constant speed in a circle with a circumference of 6.0 m. The string is held parallel to the table, and the tension in the string has a magnitude of 10 N. The friction is zero. Find the work done on the ball by each force acting as the ball makes one revolution.

a.



P = 44 N

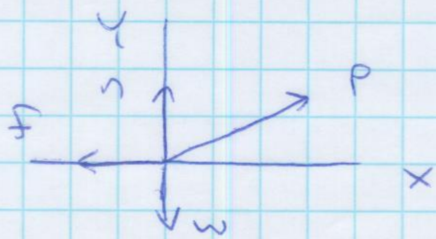
m = 20 kg

$\mu_k = 0.15$

$W_n = 0$
$W_{mg} = 0$
} $\theta = 90°$, $\cos\theta = 0$

$W_p = P d \cos\theta = (44\ N)(5\ m)\cos 35°$
$= 180\ J$

$f = \mu n.$



Not accel. up!

$\Sigma F_y = m a_y$

$n + P\sin 35° - w = 0$

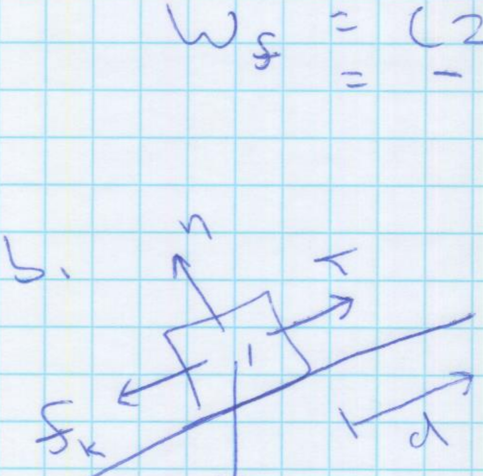
$n = (20\ kg)(9.8\ \frac{m}{s^2}) - (44\ N)\sin 35°$

$n = 171\ N$

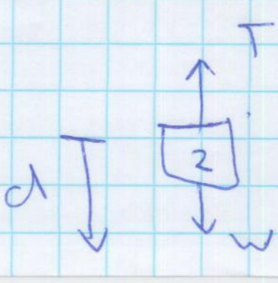
$f = \mu n = 25.6\ N$

$W_f = (25.6\ N)(5.0\ m)\cos 180°$
$= -128\ J$

b.

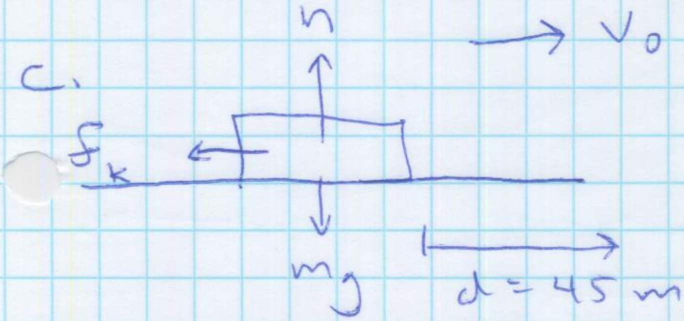


W_T	* W_n	W_f	W_{mg}
+	0	—	—



W_w	W_T
+	—

c.



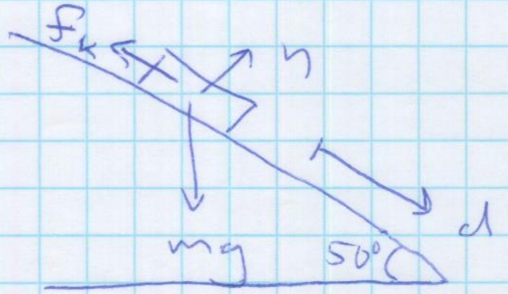
$$W_n = 0$$
$$W_{mg} = 0$$
$\Big\} \ \theta = 90^\circ$

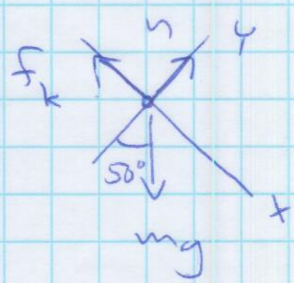
$$\Sigma F_y = ma_y$$
$$n - mg = 0$$

$$f = \mu n = \mu mg$$
$$= (0.35)(750\ kg)(9.8\ \tfrac{m}{s^2}) = 2572\ N$$

$$W_f = (f)(d)\cos\theta$$
$$= (2572\ N)(45\ m)\cos 180^\circ$$
$$= -115760\ J$$

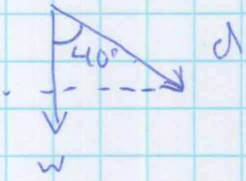
d.





$$\Sigma F_y = ma_y$$
$$n = mg\cos 50$$

$$W_n = 0 \qquad \theta = 90^\circ$$
$$W = Fd\cos\theta$$
$$W_{mg} = (4\ kg)(9.8\ \tfrac{m}{s^2})(3\ m)\cos 40^\circ$$
$$= +90\ J$$



$$W_f = fd\cos\theta$$
$$= \mu n d\cos\theta$$
$$= \mu(mg\cos 50)\ d\cos\theta$$
$$= 0.27(4\ kg)(9.8\ \tfrac{m}{s^2})\cos 50\ (3\ m)\cos 180^\circ$$
$$= -20.4\ J$$

e.

d is along the circle, in + out of paper in this view.

$$W_n = 0$$
$$W_{mg} = 0$$
$$W_T = 0$$
$\Big\}$ all $\theta = 90^\circ$