how to determine the work done by an individual force

The work done by a force over an interval indicates how much the force has changed the kinetic energy of the object of that interval.
1. Choose and label the initial and final points of the interval.
2. Draw and determine $\vec{F}$.
3. Draw $\vec{v}$. $\vec{v}$ indicates the direction of the object's motion.
4. Draw and determine $\vec{F}_{\parallel}$. $\vec{F}_{\parallel} = \vec{F}\cos\theta$, where θ is the angle between $\vec{F}$ and $\vec{v}$. $\vec{F}_{\parallel}$ is the component of the force which is parallel to $\vec{v}$. Only the component of the force in the direction of the object's motion can affect the object's speed, and hence only this component can affect the object's kinetic energy, and hence only this component can do work. (The other component, $\vec{F}_{\perp}$, affects the object's direction, not its speed and kinetic energy.) If the force is perpendicular to $\vec{v}$, then $\vec{F}_{\parallel}$=0, so the *W*=0; a force that is perpendicular to motion changes only the object's direction, not its speed or kinetic energy, so it does no work.
5. Determine the sign of *W*. If $\vec{F}_{\parallel}$ is parallel to $\vec{v}$, then *W* is positive. If $\vec{F}_{\parallel}$ is antiparallel to $\vec{v}$, then *W* is negative. (Pushing in the direction of motion increases kinetic energy, doing positive work; opposing motion decreases kinetic energy, doing negative work.)
6. Determine $\vec{W} = \vec{F}_{\parallel} \cdot \Delta\vec{r}$, unit = Joule = J = $\mathrm{N \cdot m}$ (Since $\vec{F}_{\parallel} = \vec{F}\cos\theta$, we are really using the formula $\vec{W} = \vec{F} \cdot \Delta\vec{r} \cdot \cos\theta$.)

After you determine the work done by all the individual nonconservative forces, you can use "net $W_{nc} = \Delta E$".

energy

unit = Joule = J = $N \cdot m$	
translational kinetic energy	tr$K = \frac{1}{2} m\dot{v}^2$
rotational kinetic energy	rot$K = \frac{1}{2} I\omega^2$
gravitational potential energy	grav $U = mgh$ h = vertical height You can choose where h=0. Δgrav$U = mg\Delta h$
spring potential energy	sp$U = \frac{1}{2} kx^2$ x is the spring's displacement from its natural length
total mechanical energy	E = tr$K$ + rot$K$ + grav$U$ + sp$U$ E includes all relevant kinetic and potential energies.

work and energy

net $W_{all} = \Delta K$ the "work-energy theorem" This tells us the nature of work: the work done by a force indicates how the force is changing the object's kinetic energy.
$W_{con} = -\Delta U$
net $W_{nc} = \Delta E$ If net W_{nc} = 0, then ΔE=0, so E_i=E_f (conservation of mechanical energy).

The work-energy theorem is useful for understanding the nature of work, but is seldom used for solving problems. For problem-solving we generally use "net $W_{nc} = \Delta E$", or, when net W_{nc}=0, we use "E_i=E_f" (conservation of mechanical energy).

How to use "net $W_{nc} = \Delta E$" and "E_i=E_f" (conservation of mechanical energy) to solve problems

1. Identify and label the initial and final points of the interval you are considering.	
2. Identify all the forces on the object. Separate them into conservative forces (weight, spring force, and electric force) and nonconservative forces (pretty much everything else you'll see in the course). Only work done by nonconservative forces should be included in "net W_{nc}".	
3. Identify the work done by each nonconservative force, including signs, and plug them into the left side of the equation as "net W_{nc}". If a force is perpendicular to the object's movement, it does no work. If an object is rolling without slipping: (1) No slipping means no sliding, so the object experiences static rather than kinetic friction. (2) The point in contact with the ground is momentarily motionless; this means that the friction force is doing no work, since the point in contact with the ground moves zero distance while the friction force is acting on it (remember that work=force×distance).	
4. If net $W_{nc} \neq 0$, use "net $W_{nc} = \Delta E$". net $W_{nc} = \Delta \text{tr}K + \Delta \text{rot}K + \Delta \text{grav}U + \Delta \text{sp}U$ net $W_{nc} = \text{tr}K_f - \text{tr}K_i + \text{rot}K_f - \text{rot}K_i + \text{grav}U_f - \text{grav}U_i + \text{sp}U_f - \text{sp}U_i$	4. If net W_{nc}=0, then ΔE=0, so use "E_i=E_f" (conservation of energy) $\text{tr}K_i + \text{rot}K_i + \text{grav}U_i + \text{sp}U_i = \text{tr}K_f + \text{rot}K_f + \text{grav}U_f + \text{sp}U_f$
5. Work out the terms for the object's energy, and plug into the equation from step four. Be careful with signs; look for terms that are zero. If the object's speed is unchanging, then $\Delta \text{tr}K$= 0. When the object is at rest (for example, starting from rest or coming to rest), then tr$K$=0. Remember that an object is "at rest" (v=0) in the instant that its direction changes, so in that instant tr$K$=0. If an object isn't rotating (for example, when it is starting from rest or coming to rest), then rot$K$=0. If an object's rotational speed is unchanging, then Δrot$K$=0. If an object's rotational speed in an instant is 0, then rot$K$=0 in that instant. Remember that rotational speed is 0 in the instant that the direction of rotation reverses, so in that instant rot$K$=0. If an object's vertical height is unchanging, then Δgrav$U$=0. You can choose the point that represents zero height. If an object is not attached to a spring, or if the spring isn't moving, or if the spring's initial and final positions are the same, then Δsp$U$=0. When an spring is at it's natural length, x=0 so sp$U$=0.	
6. If necessary, use $\dot{v} = \dot{r}\dot{\omega}$ to substitute for v or ω.	
7. To get as many equations as unknowns, you may need to use other equations, such as: net $F_x=ma_x$, net $F_y=ma_y$, and net $\tau = I\alpha$.	
8. When you have as many equations as unknowns, solve one of the equations for a variable and substitute for that variable into the remaining equations; repeat as many times as necessary.	

Newton's Second Law is useful for problems about force and acceleration; Newton's Second Law plus kinematics is useful for solving problems about time. Work and energy are useful for problems about force, distance, and speed. Conservation of linear momentum is useful for problems about brief collisions and separations.