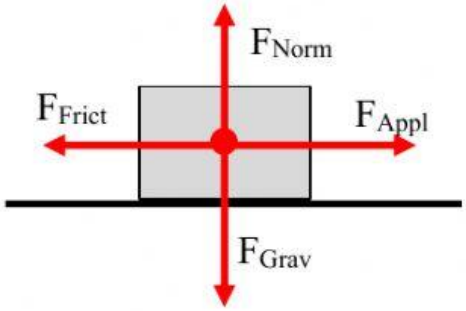
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PHYSICS
Surface-Dependent Free Body Diagrams: Basic Problems

Gravity force $F_{Grav} = w = m \cdot g$	w = weight (N) g = acceleration due to gravity (9.81 m/s^2) m = mass (kg)
Normal force $F_{Norm} = F_{Grav} \cdot \cos\phi$	F_{Grav} = weight (N) ϕ = slope angle of surface (degrees)
Friction force $F_{Frict} = F_{Norm} \cdot \mu$	F_{Norm} = normal force (N) μ = friction coefficient (values 0 to 1.0)
Applied force (unassisted) $F_{Appl} = F_{Grav} \cdot \sin\phi$	F_{Grav} = weight (N) ϕ = slope angle of surface (degrees)
Additional external force F_{ext}	Any additional force added to the system. It is usually a push or pull to an object. The external force most of the time is in same direction as the applied force, but not always.
Net force $F_{net} = F_{Appl} \pm F_{ext} - F_{Frict}$	F_{net} = net force (N) F_{frict} = friction force (N) F_{appl} = applied force (N) F_{ext} = additional external force (N)
Acceleration $a = \frac{F_{net}}{m}$	F_{net} = Net force (N) a = acceleration (m/s^2) m = mass (kg)

LIVEWORKSHEETS

Part 1: Free body diagrams on horizontal surfaces. Calculate the values of the forces and acceleration affecting the object. All external forces are parallel to the surface. Do your best to type the equations and answers into the boxes.

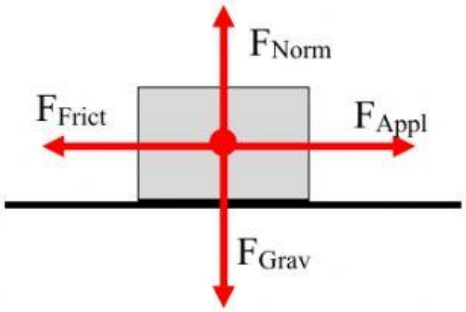


A. **Horiontal surface**. A crate on the floor. Jeremy pushes the 50 kg crate across the wood floor with a push force of 188 N. The kinetic friction coefficient for is $\mu = 0.33$. Assume that the push is parallel to the floor. The horizontal surface has a slope of $\phi = 0°$.



$F_{Grav} =$
$F_{Norm} =$
$F_{Frict} =$
$F_{Appl} =$
$F_{net} =$
$a =$

LIVEWORKSHEETS



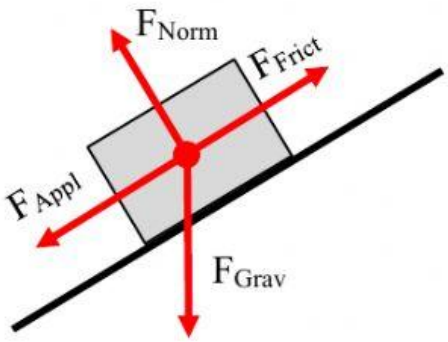
B. **Horizontal surface**. Corey's car ran out of gasoline. He had to push the car to the filling station. He pushed the car with a force of 4900 N. The mass of the car is 1200 kg. The rolling friction coefficient for the car's wheels on the pavement is $\mu = 0.40$. The horizontal surface has a slope of $\phi = 0°$.



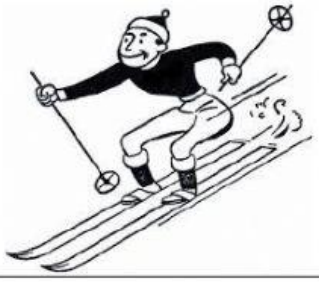
F_{Grav} =
F_{Norm} =
F_{Frict} =
F_{Appl} =
F_{net} =
a =

LIVEWORKSHEETS

Free body diagrams on sloping surfaces. Calculate the values of the forces and acceleration affecting the object. All external forces are parallel to the surface. Do your best to type the equations and answers into the boxes.

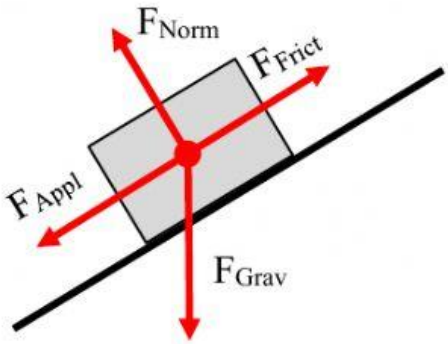


C. **Sloping surface**. Franz is skiing in the Alps. He has a mass of 85 kg. He is skiing down the 16° icy slope only under the influence of gravity. There are no other forces assisting him. The friction coefficient between his skis and the snow is 0.12.

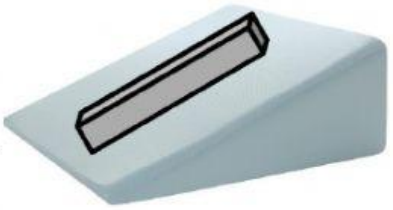


F_{Grav} =
F_{Norm} =
F_{Frict} =
F_{Appl} =
F_{net} =
a =

LIVEWORKSHEETS



D. **Sloping surface**. A 500 kg steel beam lies on a sloping concrete barrier. The rise angle of the concrete barrier is $\phi = 24°$. The kinetic friction coefficient of the concrete is $\mu = 0.50$. You push with an extra force of 450 N downslope.



F_{Grav} =
F_{Norm} =
F_{Frict} =
F_{Appl} =
F_{net} =
a =

LIVEWORKSHEETS