Chapter 6 Discussion
1D Dynamics

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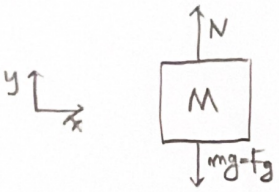
1. If you know all of the forces acting on a moving object, can you tell in which direction the object is moving? If the answer is Yes, explain how. If the answer is No, give an example.

No, the forces are not directly related to the velocity.

Net force only decide the acceleration.

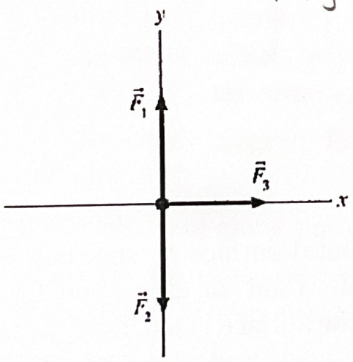


: this object can go either left or right or at rest.

2. The figures show free-body diagrams for an object of mass m. Write the components of the net force in terms of magnitudes and any given angles.

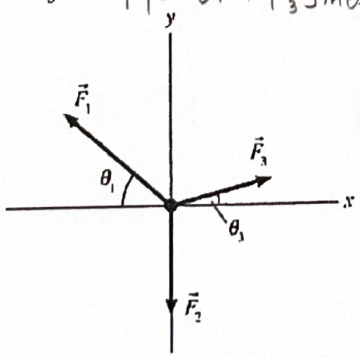
(a) $\Sigma F_x = F_3 = ma_x$

$\Sigma F_y = F_1 - F_2 = ma_y = 0$



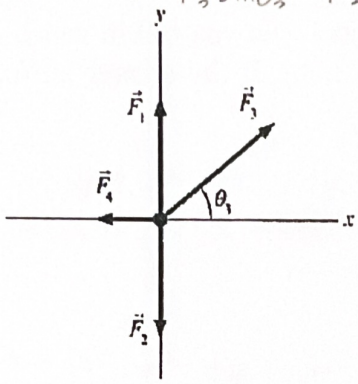
(b) $\Sigma F_x = F_3 \cos\theta_3 - F_1 \cos\theta_1 = ma_x$

$\Sigma F_y = F_1 \sin\theta_1 + F_3 \sin\theta_3 - F_2 = ma_y$



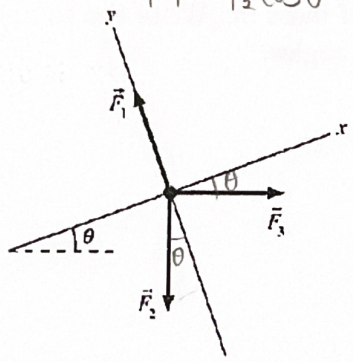
(c) $\Sigma F_x = F_3\cos\theta_3 - F_4 = ma_x$

$\Sigma F_y = F_1 + F_3\sin\theta_3 - F_2 = ma_y$

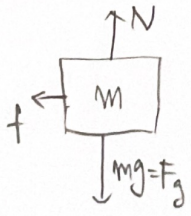


(d) $\Sigma F_x = F_3\cos\theta - F_2\sin\theta = ma_x$

$\Sigma F_y = F_1 - F_2\cos\theta - F_3\sin\theta = ma_y$



3. A block of mass m is pushed along a rough horizontal surface at speed v_0 and then released. It slides a distance d after being released. Find an expression for d if the coefficient of kinetic friction between the block and the surface is μ_k. Does it depend on mass?



$x = x_0 + V_0 t + \frac{1}{2}at^2$

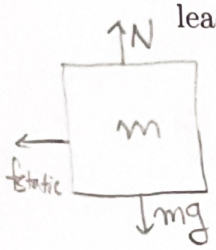
$\boxed{d = 0 + V_0 t + \frac{1}{2}(-\mu_k \cdot g)\cdot t^2}$, does not depend on mass

$\Sigma F_y = -f = -\mu_k \cdot N = -\mu_k \cdot mg = ma_y$

$a_y = -\mu_k \cdot g$

4. Consider a box in the back of a pickup truck.

   (a) If the truck accelerates slowly, the box moves with the truck without slipping. Draw a free-body diagram and calculate the maximum acceleration of the car that won't lead to slipping.



$f_{static} = \mu_s \cdot N$

$m a_{car} < \mu_s \cdot N$

$m a_{car} < \mu_s \cdot mg$

$\boxed{\therefore \mu_s \cdot g}$

   (b) If the truck accelerates at a rate greater than that found in (a), why will the box begin to slide? What will its acceleration be?

The pushing force will be greater than static friction and the box will begin to slide when box begin to slide, static friction become kinetic friction and box will accelerate to the front because pushing force will be larger than $f_{kinetic}$.

5. A small airplane of mass m must take off from a jungle airstrip that slopes upward at a slight angle θ. When the pilot pulls back on the throttle, the plane's engines exert a constant forward thurst force $\vec{F}_{Th}$. Rolling friction is not negligible on the dirt airstrip, and the coefficient of rolling resistance is μ_r. If the plane's takeoff speed is v_T, what minimum length must the airstrip have for the plane to get airborne?

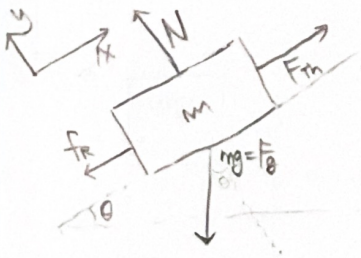
   (a) Draw a free-body diagram for the plane. Be sure to choose an appropriate coordinate system.

   (b) Find the net force along both coordinate axes. Apply Newton's 2nd Law.

   (c) Combine the expression for rolling friction with your above equations to find the x-component of the acceleration, a_x.

   (d) Use kinematics to find the minimum length of the runway.

(a)



(b)

$\Sigma F_x = F_{Th} - f_R - F_g \sin\theta = m a_x$

$\Sigma F_y = N - F_g \cos\theta = m a_y = 0$

$\Sigma F_x = F_{Th} - \mu_r \cdot mg - mg \sin\theta = m a_x$

$\boxed{a_x = \frac{F_{Th}}{m} - \mu_r \cdot g \cdot \cos\theta - g \sin\theta}$

(c)

$x = \frac{1}{2} a_x t^2$

$V_T = 0 + at$

$\frac{V_T}{a_x} = t$

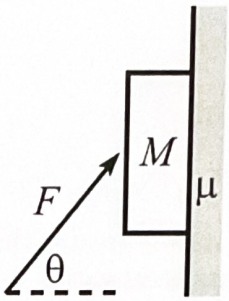
$x = \frac{1}{2} a \frac{V_T^2}{a^2} = \frac{V_T^2}{2a}$

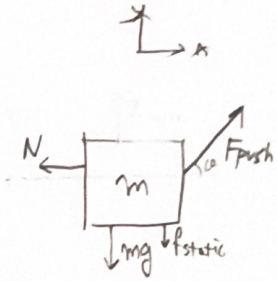
$x = \frac{V_T^2}{2a}$

$= \boxed{\frac{V_T^2}{2\left(\frac{F_{Th}}{m} - \mu_r \cdot g \cdot \cos\theta - g \sin\theta\right)}}$

(d)

6. A book of mass M is positioned against a vertical wall. The coefficient of static friction between the book and the wall is μ_s. You wish to keep the book at rest by pushing on it with a force F applied at an angle θ with respect to the horizontal ($-\pi/2 < \theta < \pi/2$), as shown.





(a) For a given θ, what is the *minimum* F required?

$\Sigma F_x = F\cos\theta - N = 0$

$\Sigma F_y = F\sin\theta - mg - f_{static} = 0$

$F\cos\theta = N$

$F\sin\theta = mg + \mu_s N$

$f_s = F\sin\theta - mg$

$f_s \le \mu_s F\cos\theta$

$F\sin\theta - mg \le \mu_s F\cos\theta$

$F\sin\theta - \mu_s F\cos\theta \le mg$

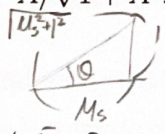
$$\boxed{F \ge \frac{mg}{\sin\theta + \mu_s\cos\theta}}$$

(b) For what θ is this minimum F the smallest? (Hint: calculus). What is the corresponding minimum F? (Hint: If $\cot\theta = A$, think of this as $\cot\theta = \frac{A}{1}$ and draw a triangle to show $\sin\theta = 1/\sqrt{1+A^2}$ and $\cos\theta = A/\sqrt{1+A^2}$.)

$\sin\theta + \mu_s\cos\theta$ has to be maximum

derivative : $\cos\theta - \mu_s\sin\theta$

when derivative became 0 the value → max



$\cos\theta = \mu_s\sin\theta$

$\mu_s = \tan^{-1}(\theta)$

$\therefore F_{min} = \frac{mg}{\sqrt{1+\mu_s^2}}$

(c) What is the limiting value of θ, below which there does not exist an F that keeps the book up?

$\mu_s = \tan^{-1}\theta$ $\quad \frac{1}{\mu_s} = \tan\theta$, $\quad \theta = \tan^{-1}\left(\frac{1}{\mu_s}\right)$

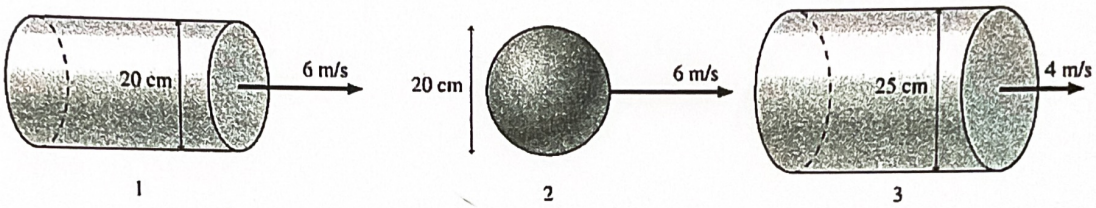
(d) What is the *maximum* value of F, beyond which the book will start to slide up the wall?

slide up means friction down

$$F_{max} = \frac{Mg}{\sin\theta - \mu_s\cos\theta}$$

7. Consider the turbulent (quadratic) drag force $F_D = \frac{1}{2}C\rho A v^2$.

(a) Three objects move through the air as shown. Rank the drag forces F_D on the three objects. Some may be equal; give your answer in the form $A > B = C > D$. Note that for a sphere, $C \approx 0.5$, while for a cylinder moving axially through the fluid, $C \approx 0.8$.

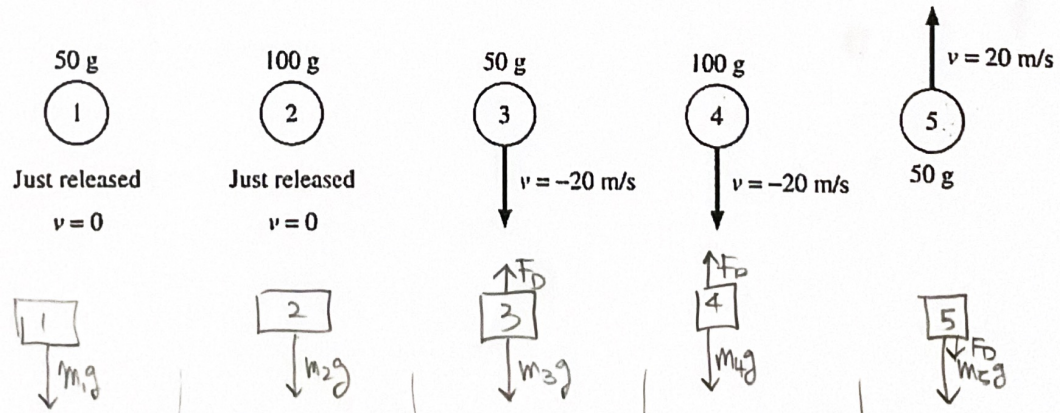


$F_D \propto Av^2$

1	2	3
$A_1 = \pi(0.1)^2$	$A = \pi(0.1)^2$	$A = \pi(0.125)^2$
$v^2 = 36$	$v^2 = 36$	$v^2 = 16$
$Av^2 = 0.36\pi$	$Av^2 = 0.36\pi$	$Av^2 = 0.25\pi$

$\boxed{1 = 2 > 3}$

(b) Five balls move through the air as shown. They all have the same size and shape. Rank in order the magnitude of their accelerations a_1 through a_5. Some may be equal; give your answer in the form $A > B = C > D$.



	1	2	3	4	5
$F_g =$	50g	100g	50g	100g	50g
F_D	×	×	only v^2		

$5 > 1 = 2 > 4 > 3$