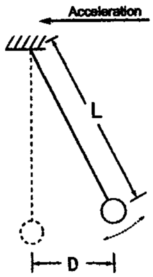
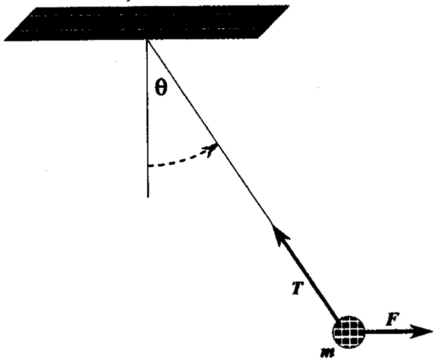
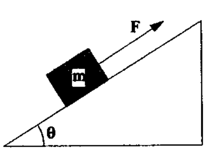
1. [2pt] A pendulum has a length $L = 1.00\ m$. It hangs straight down in a jet plane at rest, as shown by the dotted line in the figure. Then the jet accelerates uniformly, and during that time, the pendulum moves to the equilibrium position shown by the solid line, with $D = 0.34\ m$. What is the acceleration of the plane?



2. [2pt] In the diagram above, the horizontal force F holds the ball steady. Given $F = 8.5\ N$, and $\theta = 10°$, calculate the mass of the ball.



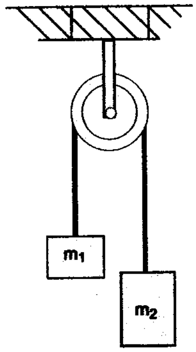
3. [2pt] A block weighing 74.0 N rests on a plane inclined at 23.1° to the horizontal. The coefficients of static and kinetic friction are 0.25 and 0.12 respectively. What is the minimum magnitude of the force F, parallel to the plane, that will prevent the block from slipping?



4. [2pt] A man wants to push a package of shingles of total mass 22 kg up a roof being built at an angle of 35° to the horizontal. The coefficient of kinetic friction between the package and the roofing paper already in place is 0.31. How much force does the man have to exert on the package directly along the slope of the roof to cause the package to accelerate at 0.1 m/s^2?

5. [2pt] What is the minimum coefficient of static friction needed so that the package will not slide when it is left at rest on the roof?

6. [2pt] In the diagram, the pulley is frictionless and the ropes are massless. Given that $m_1 = 10.0\ kg$ and $m_2 = 27.0\ kg$, calculate the acceleration of m_2 downwards.



7. [2pt] The tallest spot on Earth is Mt. Everest, which is 8856 m above sea level. If the radius of the Earth to sea level is 6366 km, how much does the magnitude of g change between sea level and the top of Mt. Everest?

8. [2pt] An astronaut weighs 694 N on the Earth. What is her weight on planet X, which has a radius $R_x = R_{earth}$ / 1.60 and a mass $M_x = M_{earth}$ / 7.30?

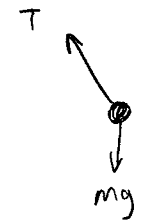
9. [2pt] Using the measured values of the gravitational acceleration g, the gravitational constant G, and taking the radius of the Earth to be 6480 km, find the mass of the Earth.

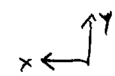
10. [2pt] Using the values from the previous question calculate the average density of the Earth.

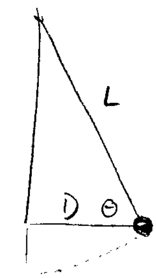
Assign (4)

(1) $\cos\theta = \frac{D}{L}$ (known...)

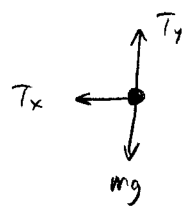
Object: the ball







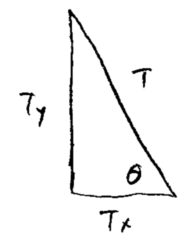
redraw:



Note: $\frac{T_x}{T} = \frac{D}{L}$

$T_x = T\cos\theta$

Also, $T_y = T\sin\theta$



$\Sigma F_y = m\cancel{a_y}^{\,0}$

$+T_y - mg = 0$

$T\sin\theta = mg$

$T = \frac{mg}{\sin\theta}$

$\Sigma F_x = ma_x$

$+T_x = ma$

$T\cos\theta = ma$

$\left(\frac{mg}{\sin\theta}\right)\cos\theta = ma \rightarrow \boxed{a = \frac{g}{\tan\theta}}$

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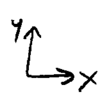
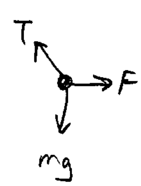
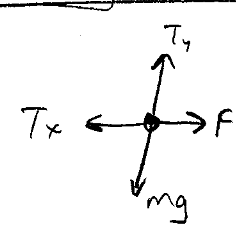
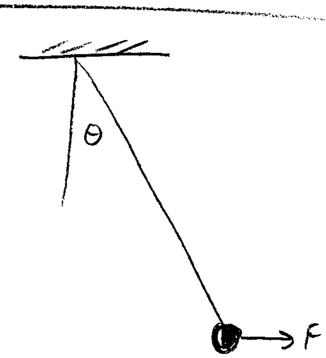
(2) object: ball









$\Sigma F_y = m\cancel{a_y}^{\,0}$

$+T_y - mg = 0$

$T = \frac{mg}{\cos\theta}$

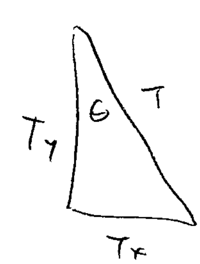
$T_x = T\sin\theta$

$T_y = T\cos\theta$

$\Sigma F_x = m\cancel{a_x}^{\,0}$

$F - T\sin\theta = 0$

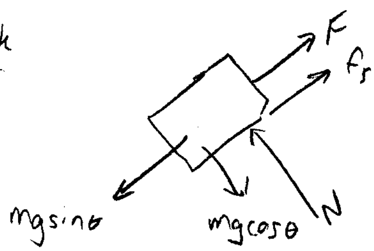
$F = T\sin\theta$



$F = mg\frac{\sin\theta}{\cos\theta} \rightarrow F = mg\tan\theta$, or

$$\boxed{m = \frac{F}{g\tan\theta}}$$

(3) Object: block



$\Sigma F_y = m\cancel{a_y}^{0}$

$+N - mg\cos\theta = 0$

$N = mg\cos\theta$

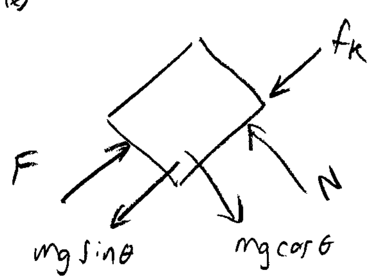
$\Sigma F_x = m\cancel{a_x}^{0}$

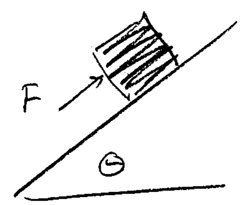
$+F + f_s - mg\sin\theta = 0$

$+F + \mu_s(mg\cos\theta) - mg\sin\theta = 0$

$$\boxed{F = mg(\sin\theta - \mu\cos\theta)}$$

(4) Object: shingles





$\Sigma F_y = m\cancel{a_y}^{0}$

$N = mg\cos\theta$

$\Sigma F_x = ma_x$

$+F - mg\sin\theta - f_k = ma$

$F - mg\sin\theta - \mu_k \cdot mg\cos\theta = ma$

$$\boxed{F = m(a + g\sin\theta + \mu_k g\cos\theta)}$$

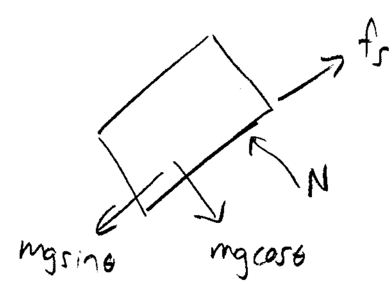
(5) In this case ⟶

$\Sigma F_y = 0 \rightarrow N = mg\cos\theta$

$\Sigma F_x = 0$

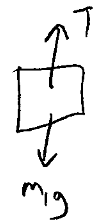
$f_s - mg\sin\theta = 0$

$\mu_s(mg\cos\theta) = mg\sin\theta$



$$\boxed{\mu_s = \tan\theta}$$

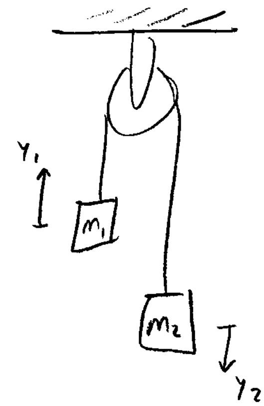
(6) Object is m_1:



$$\Sigma F_y = m_1 a_{y_1}$$

$$T - m_1 g = m_1 a$$

$$T = m_1 (a + g)$$



Object is m_2:

$$\Sigma F_y = m_2 a_y$$

$$+m_2 g - T = m_2 a$$

Algebra:

$$m_2 g - (m_1 a + m_1 g) = m_2 a$$

$$(m_2 - m_1) g = (m_2 + m_1) a$$

$$\boxed{a = g\left(\frac{m_2 - m_1}{m_1 + m_2}\right)}$$

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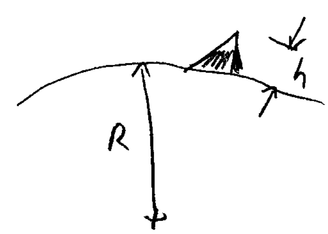
(7) $h = 8856\text{ m}$

$R = 6{,}366{,}000\text{ m}$



$$W = mg = G\frac{m M_E}{r^2}$$

$$g = \frac{G M_E}{r^2}$$

$$\Delta g = g_1 - g_2 = \boxed{G M_E\left(\frac{1}{R^2} - \frac{1}{(R+h)^2}\right) = \Delta g}$$

---

(8) $W_E = G\frac{m M_E}{R_E^2}$ let $R_x = \frac{R_E}{a}$, and $M_x = \frac{M_E}{b}$

$Gm = \frac{W_E R_E^2}{M_E}$ $a = 1.60$, $b = 7.30$

$$W_x = \frac{G m M_x}{R_x^2} = \frac{W_E R_E^2 M_x}{M_E R_x^2} = \boxed{\frac{W_E a^2}{b} = W_x}$$

(9) $mg = \frac{G m m_E}{R_E^2}$ $\boxed{m_E = \frac{g R_E^2}{G}}$

using $R_E = 6480$ km $\rightarrow$ $m_E = 6.17 \times 10^{24}$ kg

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(10) $\rho = \frac{m}{V} = \boxed{\rho = \frac{3m}{4\pi R_E^3}}$ $\boxed{\rho = 5413 \text{ kg/m}^3}$

Note : $\rho_{water} = 1000$ kg/m^3
$\rho_{iron} \simeq 8000$ kg/m^3

So this is somewhere between.