Section II: Free Response

1. A robot probe lands on a new, uncharted planet. It has determined the diameter of the planet to be 8×10^6 m. It weighs a standard 1 kg mass and determines that 1 kg weighs only 5 newtons on this new planet.

   (a) What must the mass of the planet be?

   (b) What is the acceleration due to gravity on this planet? Express your answer in both m/s^2 and g's (where 1 g = 10 m/s^2).

   (c) What is the average density of this planet?

2. The Earth has a mass of 6×10^{24} kg and orbits the Sun in 3.15×10^7 seconds at a constant radius of 1.5×10^{11} m.

   (a) What is the Earth's centripetal acceleration around the Sun?

   (b) What is the gravitational force acting between the Sun and Earth?

   (c) What is the mass of the Sun?

3. An amusement park ride consists of a large cylinder that rotates around its central axis as the passengers stand against the inner wall of the cylinder. Once the passengers are moving at a certain speed, v, the floor on which they are standing is lowered. Each passenger feels pinned against the wall of the cylinder as it rotates. Let r be the inner radius of the cylinder.

   (a) Draw and label all the forces acting on a passenger of mass m as the cylinder rotates with the floor lowered.

   (b) Describe what conditions must hold to keep the passengers from sliding down the wall of the cylinder.

   (c) Compare the conditions discussed in part (b) for an adult passenger of mass m and a child passenger of mass $m/2$.

4. A curved section of a highway has a radius of curvature of r. The coefficient of friction between standard automobile tires and the surface of the highway is μ_s.

   (a) Draw and label all the forces acting on a car of mass m traveling along this curved part of the highway.

   (b) Compute the maximum speed with which a car of mass m could make it around the turn without skidding in terms of μ_s, r, g, and m.

   City engineers are planning to bank this curved section of highway at an angle of θ to the horizontal.

   (c) Draw and label all of the forces acting on a car of mass m traveling along this banked turn. Do not include friction.

   (d) The engineers want to be sure that a car of mass m traveling at a constant speed v (the posted speed limit) could make it safely around the banked turn even if the road were covered with ice (that is, essentially frictionless). Compute this banking angle θ in terms of r, v, g, and m.

Section II: Free Response

1. (a)

Given a mass of 1 kg, weight F_g = 5 N, and diameter = 8 × 10^6 m (this gives you r = 4 × 10^6 m), you can fill in this equation:

$$F_G = \frac{Gm_1m_2}{r^2} \Rightarrow m_1 = \frac{F_G r^2}{Gm_2}$$

This becomes

$$m_1 = \frac{(5\text{ N})(4\times10^6\text{ m})^2}{\left(6.67\times10^{-11}\frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}\right)(1\text{ kg})} = 1.2\times10^{24}\text{ kg}$$

(b)

$$g = \frac{Gm_1}{r^2} \Rightarrow g = \frac{\left(6.67\times10^{-11}\frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}\right)1.2\times10^{24}\text{ kg}}{(4\times10^6\text{ m})^2} = 5\text{ m/s}^2$$

Note that you could have also observed that, because a 1 kg mass (which normally weighs 10 N on the surface of the Earth) only weighed 5 N, gravity on this planet must be half the Earth's gravity.

If you want to look at it in terms of g, g is 10 m/s^2 on Earth, so you can simply convert.

$$5\text{ m/s}^2\left(\frac{1g}{10\text{ m/s}^2}\right) = 0.5g$$

(c)

Density is given by mass per unit volume ($\rho = \frac{m}{V}$). In addition, use the equation for the volume of a sphere as $V = \frac{4}{3}\pi r^3$ to get

$$\rho = \frac{m}{\frac{4}{3}\pi r^3} \Rightarrow \rho = \frac{3m}{4\pi r^3} \Rightarrow \rho = \frac{3(1.2\times10^{24}\text{ kg})}{4(3.14)(4\times10^6\text{ m})^3} \text{ or}$$

$$\rho = 4{,}480\frac{\text{kg}}{\text{m}^3}$$

2. (a)

The centripetal acceleration is given by the equation $a_c = \frac{v^2}{R}$. You also know that for objects traveling in circles (Earth's orbit can be considered a circle), $v = \frac{2\pi R}{T}$.

Substituting this v into the previous equation for centripetal acceleration, you get $a_c = \frac{4\pi^2 R}{T^2}$. This becomes $a_c = \frac{4\pi^2 1.5\times10^{11}\,\text{m}}{(3.15\times10^7\,\text{s})^2}$ = 6.0×10^{-3} m/s^2.

(b)

The gravitational force is the force that keeps the Earth traveling in a circle around the Sun. More specifically, $ma_c = (6 \times 10^{24}$ kg$)(6.0 \times 10^{-3}$ m/s$^2) = 3.6 \times 10^{22}$ N.

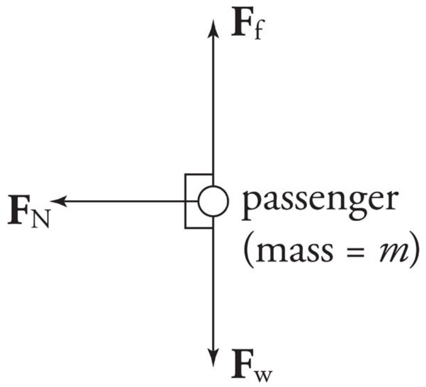
(c)

Use the Universal Law of Gravitation: $F = GmM/r^2$. You know F from the previous question, G is constant, m is the mass of the Earth (given in question), and r is the radius from Earth to Sun (also given in the question). So you can rearrange this equation to solve for M (mass of the Sun) as $M = F{\cdot}r^2/(G{\cdot}m)$ and then just plug in the appropriate values.

$F = GmM/r^2 \rightarrow M = Fr^2/(Gm) = (3.6 \times 10^{22}\ \text{N})(1.5 \times 10^{11}\ \text{m})^2/\{[6.67 \times 10^{-11}\text{Nm}^2/(\text{kg}^2)][6.0 \times 10^{24}\ \text{kg}]\} = 2.0 \times 10^{30}$

3. (a)

The forces acting on a person standing against the cylinder wall are gravity ($\mathbf{F}_w$, downward), the normal force from the wall ($\mathbf{F}_N$, directed toward the center of the cylinder), and the force of static friction ($\mathbf{F}_f$, directed upward):



(b)

In order to keep a passenger from sliding down the wall, the maximum force of static friction must be at least as great as the passenger's weight: $F_{f\,(max)} \geq mg$. Since $F_{f\,(max)} = \mu_s F_N$, this condition becomes $\mu_s F_N \geq mg$.

Now, consider the circular motion of the passenger. Neither $\mathbf{F}_f$ nor $\mathbf{F}_w$ has a component toward the center of the path, so the centripetal force is provided entirely by the normal force:

$$F_N = \frac{mv^2}{r}$$

Substituting this expression for F_N into the previous equation, you get

$$\mu_s \frac{mv^2}{r} \geq mg$$

$$\mu_s \geq \frac{gr}{v^2}$$

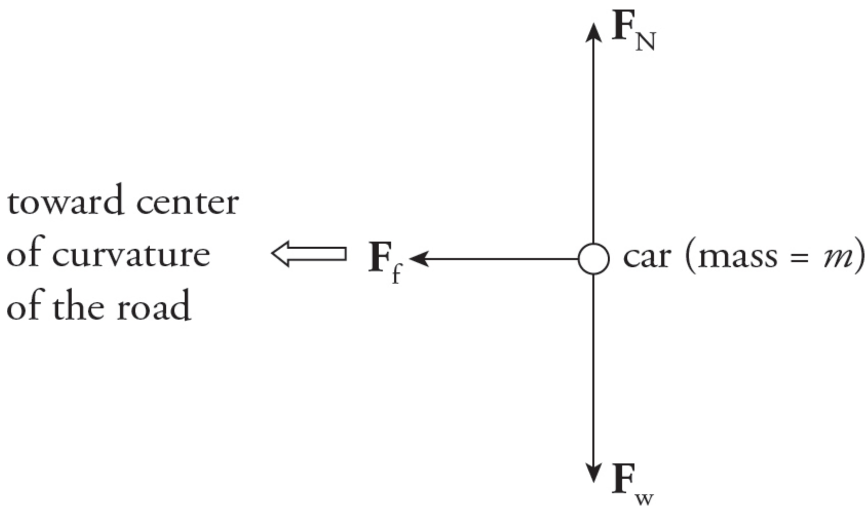
Therefore, the coefficient of static friction between the passenger and the wall of the cylinder must satisfy this condition in order to keep the passenger from sliding down.

(c)

Since the mass m canceled out in deriving the expression for μ_s, the conditions are independent of mass. Thus, the inequality $\mu_s \geq gr/v^2$ holds for both the adult passenger of mass m and the child of mass $m/2$.

4. (a)

The forces acting on the car are gravity ($\mathbf{F}_w$, downward), the normal force from the road ($\mathbf{F}_N$, upward), and the force of static friction ($\mathbf{F}_f$, directed toward the center of curvature of the road):



(b)

The force of static friction (assume static friction because you *don't* want the car to slide) provides the necessary centripetal force:

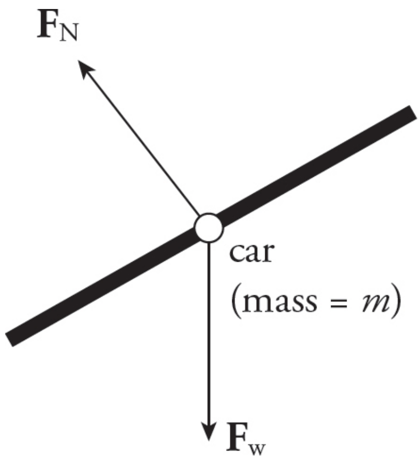
$$F_f = \frac{mv^2}{r}$$

Therefore, to find the maximum speed at which static friction can continue to provide the necessary force, write

$$\begin{aligned} F_{f\,(max)} &= \frac{mv_{max}^2}{r} \\ \mu_s F_N &= \frac{mv_{max}^2}{r} \\ \mu_s mg &= \frac{mv_{max}^2}{r} \\ v_{max} &= \sqrt{\mu_s gr} \end{aligned}$$

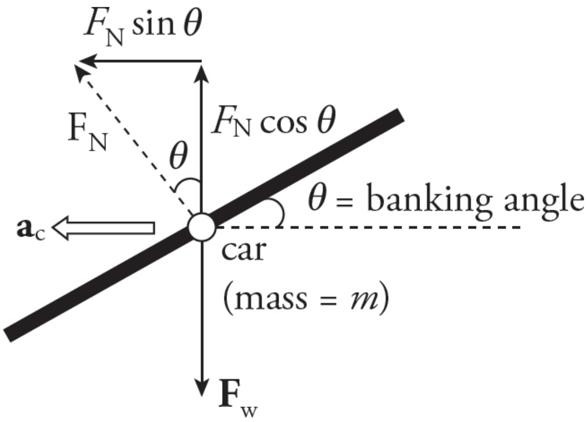
(c)

Ignoring friction, the forces acting on the car are gravity ($\mathbf{F}_w$, downward) and the normal force from the road ($\mathbf{F}_N$, which is now tilted toward the center of curvature of the road):



(d)

Because of the banking of the turn, the normal force is tilted toward the center of curvature of the road. The component of $\mathbf{F}_N$ toward the center can provide the centripetal force, making reliance on friction unnecessary.



However, there's no vertical acceleration, so there is no net vertical force. Therefore, $F_N \cos\theta = F_w = mg$, so $F_N = mg/\cos\theta$. The component of F_N toward the center of curvature of the turn, $F_N \sin\theta$, provides the centripetal force:

$$F_N \sin\theta = \frac{mv^2}{r}$$

$$\frac{mg}{\cos\theta}\sin\theta = \frac{mv^2}{r}$$

$$g\tan\theta = \frac{v^2}{r}$$

$$\theta = \tan^{-1}\frac{v^2}{gr}$$

CrackAP.com

For more AP practice tests, please visit www.crackap.com or links below.

AP World History Practice Tests
AP US History Practice Tests
AP European History Practice Tests
AP US Government and Politics Practice Tests
AP Psychology Practice Tests
AP Biology Practice Tests
AP Chemistry Practice Tests
AP Macroeconomics Practice Tests
AP Microeconomics Practice Tests
AP Statistics Practice Tests
AP English Language and Composition Practice Tests
AP English Literature and Composition Practice Tests
AP Calculus AB Practice Tests
AP Calculus BC Practice Tests
AP Physics 1 Practice Tests
AP Physics 2 Practice Tests
AP Physics C: Mechanics Practice Tests
AP Physics C: Electricity and Magnetism Practice Tests

AP practice tests download
https://www.crackap.com/ap-downloads/

AP Prep Books
https://www.crackap.com/ap-books/