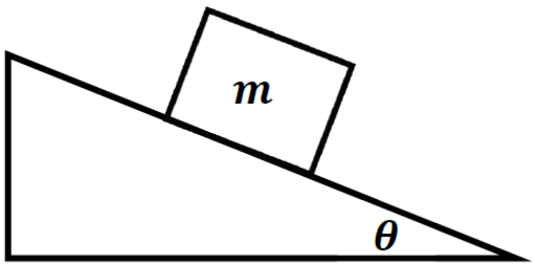
PH 220 Homework Assignment Chapter on Forces II and Uniform Circular Motion – 33 Problems Total

1. Estimate what the steepest angle of a street can a parked car not slide if you assume the coefficient of static friction between the rubber of the tires and the pavement of the road is 0.950?



Solution for Problem 1

2. What is the maximum acceleration a car can undergo on a horizontal surface if the coefficient of static friction between the tires and the road is 0.950?

Solution for Problem 2

3. A $35.0\ \mathrm{kg}$ mass is released from rest and accelerates down a plane inclined by an angle of $37.5°$ with respect to the horizontal. The mass experiences an acceleration down the incline of $0.270\ \mathrm{^m/_{s^2}}$

(a) What is the kinetic friction force acting on the mass?

(b) What is the coefficient of kinetic friction between the mass and the inclined plane surface.

Solution for Problem 3

4. A mass $(\mathrm{m} = 3.76\ \mathrm{kg})$ is given an initial speed of $4.98\ \mathrm{^m/_s}\ (\widehat{\mathrm{Right}})$ as it slides on a horizontal floor which has a coefficient of kinetic friction between the mass and the floor of $\mu_k = 0.176$. How far will the mass slide before it comes to rest?

Solution for Problem 4

5. When we consider a car driving the force that propels the car is actually static friction not kinetic friction. The car's tire is momentarily at rest with the road surface and it is the maximum static friction force which acts on the car. In comparison, if the tires were using kinetic friction the tires would be sliding on the road not actually having traction.

(a) Derive that the minimum stopping distance for a car on a road which is traveling with a speed v is the relationship $d_{stop} = \frac{v^2}{2\mu_s g}$. μ_s is the coefficient of static friction between the tire and road surface. g is the acceleration of gravity.

(b) Determine the stopping distance for a $1500.\,kg$ vehicle traveling with a speed of $26.4\ {}^{m}/_{s}$ and a coefficient of static friction between the tires and the road of $\mu_s = 0.756$.

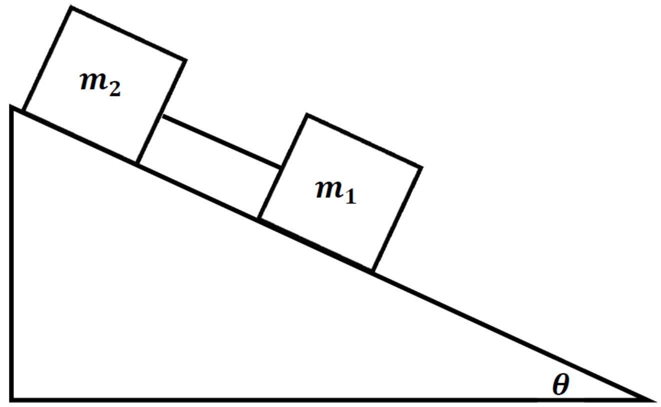
(c) Determine the stopping distance for the same car and speed, but the road is now icy and the coefficient of static friction has dropped to $\mu_s = 0.189$.

Solution for Problem 5

6. At a crash site, a pair of $84.0\ m$ skid marks were found. Assume the coefficient of kinetic friction between the road and the tires was $\mu_k = 0.745$. Also assume the road is level. Estimate how fast the vehicle was traveling before slamming on the brakes and creating the skid marks.

Solution for Problem 6

7. Two masses (m_1, m_2) are made of different materials are at rest on an inclined plane which makes an angle θ with the horizontal. There is a massless, stretchless, and unbreakable cord which joins the two masses. This is illustrated here:



We know that $(m_1 = 3.50 \text{ kg}), (m_2 = 6.25 \text{ kg}), \text{and } (\theta = 28.0°)$. In addition, the mass 1 has no friction with the inclined plane so $\mu_{s1} = 0.00$.

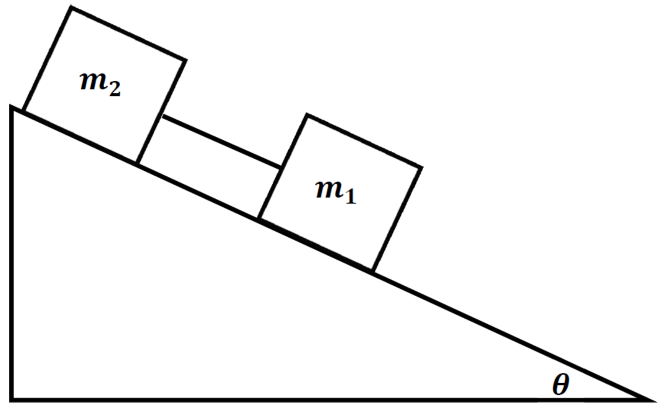
(a) What is the static friction force acting on mass m_2?

(b) What is the smallest coefficient of static friction between mass m_2 and the inclined plane necessary for these two masses to remain at rest?

(c) What is the tension force present in the cord between the two masses?

Solution for Problem 7

8. Two masses (m_1, m_2) are made of different materials are accelerating down an inclined plane which makes an angle θ with the horizontal. There is a massless, stretchless, and unbreakable cord which joins the two masses. This is illustrated here:



We know that $(m_1 = 3.50 \text{ kg}), (m_2 = 6.25 \text{ kg}), \text{and } (\theta = 28.0°)$. The coefficient of kinetic friction between the inclined plane and mass 1 is $\mu_{k1} = 0.300$, while the coefficient of kinetic friction between the inclined plane and mass 2 is $\mu_{k2} = 0.400$.

(a) What is the acceleration of the two masses down the incline plane?

(b) What is the tension force present in the cord between the two masses?

(c) What is the kinetic friction force on mass 1?

(d) What is the kinetic friction force on mass 2?

Solution for Problem 8

9. While moving, Steve and a friend place a large heavy desk $(m_{Desk} = 68.2\ kg)$on the roof of his car. The coefficient of static friction between the desk and the car roof is 0.734. What is the greatest acceleration (either increasing or decreasing) the car can use before the desk begins to slide off the roof?

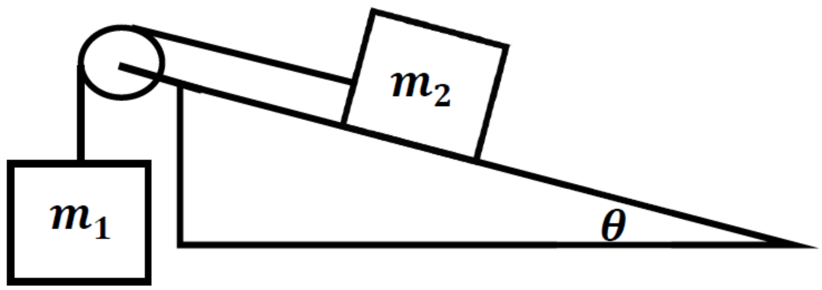
Solution for Problem 9

10. In a mail sorting facility a package $\left(m_{Package} = 11.1\ kg\right)$ is dropped vertically onto a conveyor belt to move the package through the sorting system. The speed of the conveyor belt is $(v_{belt} = 1.75\ {}^{m}/{}_{s})$The coefficient of kinetic friction between the package and the belt is $(\mu_k = 0.436)$.

(a) How long will it take for the package to stop sliding on the belt and come to rest relative to the belt? At that point the package moves along as the belt moves.

(b) How far along the belt will the pack slide before it comes to rest?

Solution for Problem 10



11. As shown above, two masses $(m_1 = 2.20\ kg)$ and $(m_2 = 4.10\ kg)$ are you connected by a massless, stretchless, and unbreakable cord. Mass 2 sits on an inclined plane which makes an angle $(\theta = 17.6°)$. The coefficient of kinetic friction between the inclined plane and mass 2 is $(\mu_k = 0.193)$.

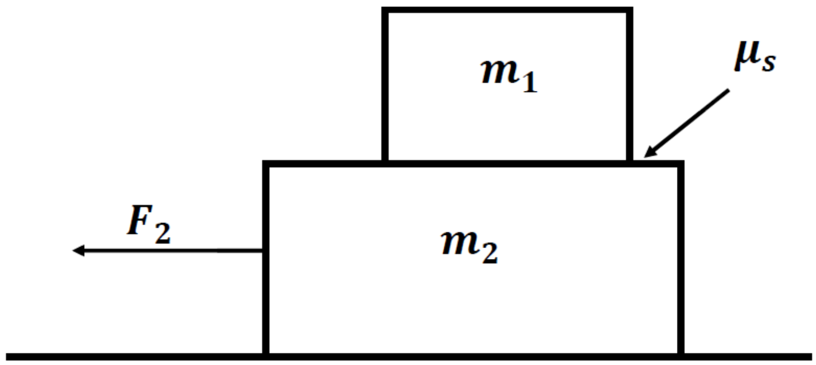
(a) What is the magnitude and direction of the acceleration of mass 1?

(b) What is the tension in the cord between mass 1 and mass 2?

(c) What is the smallest value of the coefficient of kinetic friction which would cause the masses to not move in the system.

Solution for Problem 11

12. As seen below, a mass $(m_1 = 2.65\ kg)$ is sitting on top of and at rest with a mass $(m_2 = 10.6\ kg)$ that is moving along a frictionless surface. A force $(F_2 = 97.5\ N)$ is applied to mass 2 as shown.



(a) What is the acceleration of mass 2?

(b) What is the smallest coefficient of static friction between mass 1 and mass 2 that is needed so that mass 1 does not slide relative to mass 2?

(c) If the coefficient of kinetic friction is one-third the value of the minimum coefficient of static friction found in part (b) what is the acceleration of mass 1?

(d) Using the value of the coefficient of kinetic friction used in part (c), what is the acceleration of mass2?

Solution for Problem 12

13. A car with a mass of $1500.\ kg$ is traveling around a flat curve with a radius of curvature $120.\ m$. The car had a constant speed of $27.0\ ^{m}/_{s}$. What is the minimum coefficient of static friction needed for the car to safely navigate the curve?

Solution for Problem 13

14. A table top centrifuge is used to create a centripetal acceleration of $30{,}000\ g$. The radius of the rotating chamber is $0.270\ m$. How many revolutions per minute must the centrifuge spin to create this acceleration?

Solution for Problem 14

15. A motorcycle $m_{\text{Driver and Bike}} = 1676.\ kg$ is crossing the bottom of a circular valley that has a radius of curvature of $150.\ m$. If the motorcycle rider feels an apparent weight of 2.5 times his normal weight, how fast is the motorcycle going at the bottom of the valley?

Solution for Problem 15

16. The International Space Station (ISS) orbits the Earth approximately 400 km above the surface of the Earth. The average radius of the Earth is approximately $6.40 \text{ x } 10^6 \text{ m}$. It takes the ISS about 90.0 min to complete one orbit. What is the centripetal acceleration of the ISS? Express your answer in terms of g the acceleration at the Earth's surface due to gravity.

Solution for Problem 16

17. You are riding on a Ferris Wheel ride which has a radius of 11.8 m. Your mass is 73.4 kg How many revolutions per minute would the wheel have to rotate in order for you to feel "weightless" at the highest point of the ride?

Solution for Problem 17

18. On the television show Babylon 5 (1993-1998), the space station Babylon 5 orbited the planet Epsilon III in the Epsilon Eridani star system. The station is an O'Neill cylinder that has a radius of $805. m$. The cylinder rotates to create an "artificial gravity". How many revolutions per day would be needed for the outer level to have an "Earth-like" gravity of g?

Solution for Problem 18

19. During a figure skating contest two skaters who are identical twins each having a mass of 58.0 kg and their arms have a length of 0.76 m. For one move they hold hands and make circles in which each skater completes a revolution every 1.95 s. How much tension force must their arms exert for this move to occur?

Solution for Problem 19

20. Troy is bored and cannot stop playing with the Lazy Susan on the table. The radius of the Lazy Susan is $22.7 \text{ x } 10^{-2} \text{ m}$. A glass jar of pickles is sitting on the edge of the Lazy Susan. What is the minimum coefficient of static friction necessary so that the jar $(\text{m} = 0.567 \text{ kg})$ does not slide off the Lazy Susan if Troy gets the rotation going so that there is one revolution per second?

Solution for Problem 20

21. A sports car is traveling along the road when the car passes over a rounded hill $(R_{Hill} = 97.3 \text{ m})$ with a velocity of $14.5 \text{ m}/\text{s}$. The mass of the car with the driver is $m_{CD} = 1034. \text{ kg}$ and the driver alone has a mass of $m_D = 56.7 \text{ kg}$.

(a) What is the normal force between the road and the car?

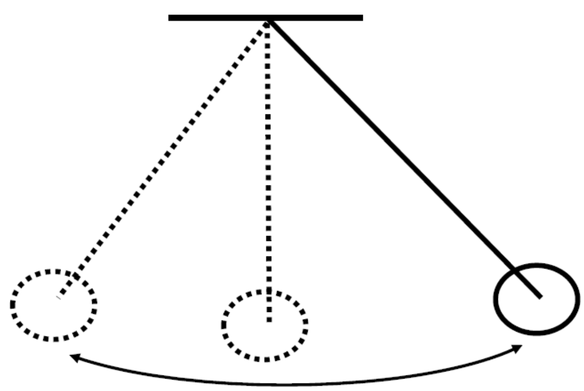
(b) What is the normal force between the car and the driver?

(c) At what speed would the car begin to leave the road?

(d) At what speed would the driver feel "weightless"?

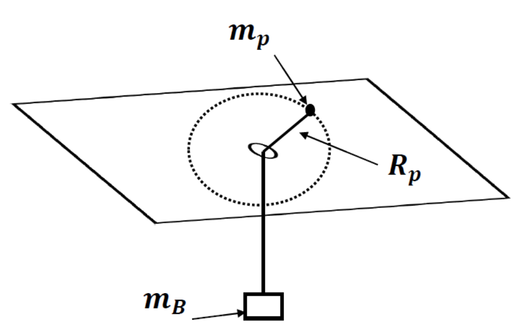
Solution for Problem 21

22. A construction wrecking ball has a mass of 30.0 kg and swings on a cable that is 7.43 m long as shown below. The cable is massless and stretchless, however, the cable will break if more than $516. \text{ N}$ of tension is applied to the cable. What is the greatest speed the wrecking ball can have at the bottom of the swing before the cable will break?



Solution for Problem 22

23. A flat air hockey puck of mass m_p is connected to a stretchless, massless and unbreakable cord. The cord passes through a hole in the air hockey table and then connects to a second mass, m_B. The puck is now moving in a circle of radius R_p on the essentially frictionless air hockey table. If the puck is circling with the appropriate speed, the block mass (m_B) will be at rest and not moving up and down in space. Find the speed of the puck as it travels in the circle in terms of m_p, m_B, and R_p.

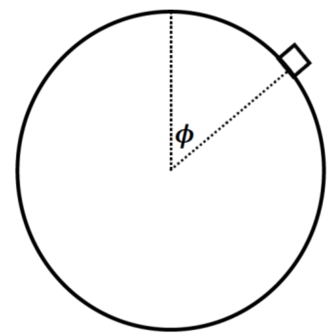


Solution for Problem 23

24. A carnival ride known as the ROTOR consists of a large circular drum $(R = 3.50\ m)$ that rotates with a speed of $30\ ^{rev}/_{min}$. The riders are pressed into the outer wall. Once the ride is up to speed the floor drops down a couple of feet. What is the minimum coefficient of friction needed to keep a rider stuck to the wall?

Solution for Problem 24

25. A small mass m is set on the surface of a sphere. At what angle ϕ will the mass begin to slide? Assume the coefficient of static friction between the mass and the sphere is $\mu_s = 0.785$.



Solution for Problem 25

26. A race car and its driver has a combined mass of $1745.\ kg$. The car is traveling at a speed of $104.\ ^{m}/_{s}$ when it enters a turn with a radius of $750.\ m$.

(a) If the curve is flat, what is the minimum coefficient of static friction μ_s between the tires and the surface of the track needed for the car to be able to safely navigate the turn?

(b) Is this value for μ_s reasonable under normal conditions?

(c) At what angle would the track surface need to be banked in order for the car to traverse the curve safely?

(d) Since it is not friction, what force is providing the centripetal acceleration needed to have the car follow the curve?

Solution for Problem 26

27. If a curve with a radius of $80.0\ m$ is properly banked for a car traveling at $75.0\ ^{km}/_{h}$, what must be a coefficient of static friction for a car not to skid when traveling at $105.\ ^{km}/_{h}$?

Solution for Problem 27

28. A banked curve of radius R for a new highway is designed so that when a car is traveling at a speed v_0, the car can take the curve safely even if there is no friction (water, ice, etc.) If the car travels too slowly, it would slide towards the bottom of the banked curve. If the car is going too fast it would slide up the bank. Static friction is necessary to oppose either of these motions and keep the car safely on the driving surface. Derive formulas to determine v_{min} and v_{max} in terms of $\mu_s, v_0,$ and R.

Solution for Problem 28

29. An object moves is a circle of radius $19.5\ \text{m}$ with a speed given by

$$v = 4.53 - 2.30t + 1.67t^2$$

With v in units of meters when t is in units of seconds. At $t = 4.00\ \text{s}$, find:

(a) The tangential acceleration

(b) The radial acceleration

Solution for Problem 29

30. An object of mass m is restricted to a circular path of radius R. Its tangential acceleration is described by

$$a_T = b + ct + dt^2$$

Where $b, c,$ and d are constants that also guarantee that a_T will have units of $^{m}/_{s^2}$ when t is in units of seconds.

If the condition $v = v_0$ when $t = 0.00\text{s}$, determine the tangential and radial components of the force acting on the object for all times $t > 0$.

Solution for Problem 30

31. A rain drop has a mass of $5 \text{ x } 10^{-5\,\text{kg}}$. It reaches a terminal velocity of about $11\ {}^{\text{m}}/_{\text{s}}$. Assume the drag force is given by the relationship:

$$F_D = bv$$

Where b is a constant and the units of the drag force will be Newtons when velocity is in ${}^{\text{m}}/_{\text{s}}$. Determine:

(a) The value of the constant b

(b) The time required for the drop to go from rest to 70% of its terminal velocity.

Solution for Problem 31

32. An object is moving vertically has $\vec{v} = \overrightarrow{v_0}$ at $t = 0$. Assume the object is acting under both the force of gravity and a resistive force $F_R = bv$. Determine the velocity as a function of time for two cases:

(a) $\overrightarrow{v_0}$ is directed downward

(b) $\overrightarrow{v_0}$ is directed upward

Solution for Problem 32

33. A block of mass m slides along a horizontal surface lubricated with a thick oil which provides a drag force proportional to the square root of velocity: $F_D = -bv^{1/2}$. Assume a boundary condition that $v = v_0$ when $t = 0$. Determine formulas for velocity and position as functions of time

Solution for Problem 33

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