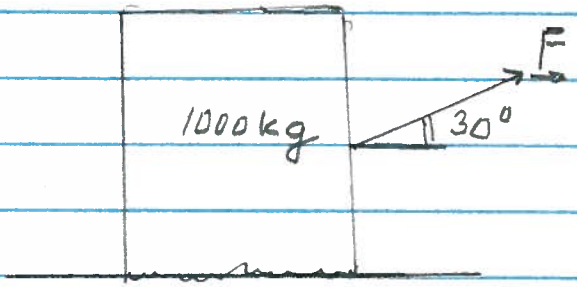
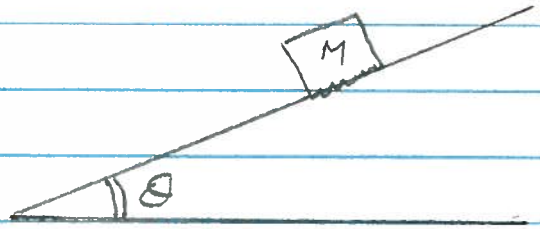
Test Questions – Exam II (Partial)

1. By applying a force of 2500N at 30° above horizontal (as shown) you are able to move a refrigerator of mass 1000kg along the floor at a constant speed. What is the kinetic coefficient of friction between the refrigerator and the floor? Why?

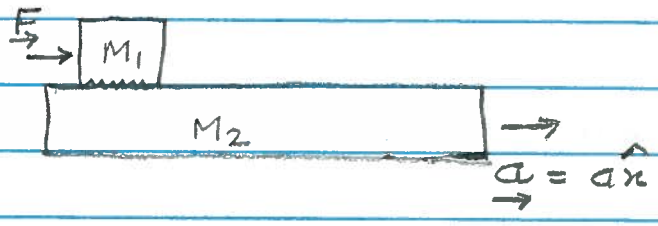


2. If the coefficient of static friction in Prob 1 was 0.26 could you move the refrigerator? Justify your answer.

3. An object of mass M is lying on a rough incline where the coefficient of static friction is 0.58. If you start increasing the angle θ for what value of θ will the object begin to slip? Why?

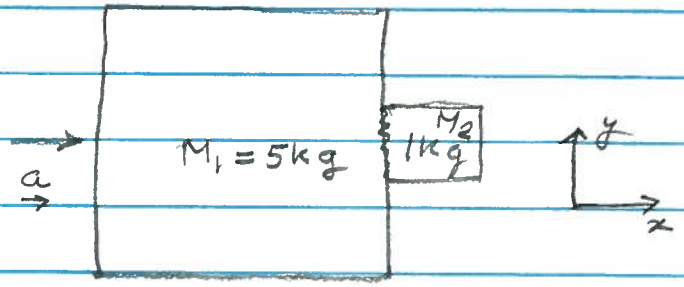


4. The Coefficient of Static friction between M_1 and M_2 is $\mu_s = 0.2$. What is the maximum value of the acceleration $\vec{a} = a\hat{x}$ for which M_1 will not slip? Why?

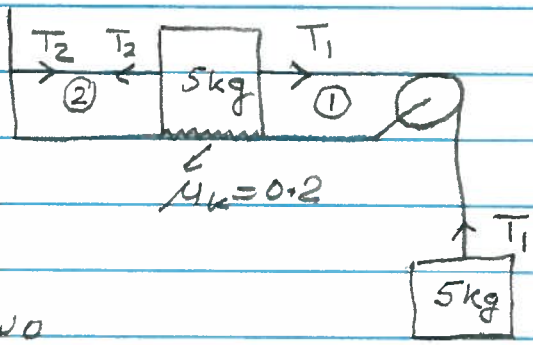


5. In Prob 4 if M_2 is lying on a smooth frictionless surface, $M_1 = 1kg$ and $M_2 = 5kg$, what is the maximum force you can apply to M_1 so that M_1 and M_2 move together? Why?

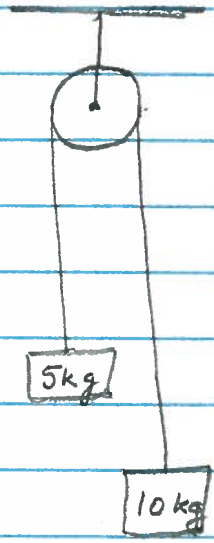
6. The Coefficient of Static friction between M_1 and M_2 is 0.3. What is the minimum value of the acceleration $a\hat{x}$ so that M_2 will not slip down? Why?



7. What are the tensions T_1 and T_2 when both strings are present? What are the accelerations of the two masses and tension T_1 when string (2) is cut? Why?



8. In the apparatus shown there is a frictional force of 20N acting on the light string at the pulley. Calculate the accelerations of the masses and the tensions in the string (hint: friction always opposes motion)



9. In uniform circular motion an object travels on a circle of radius R at a constant speed. To describe the motion precisely we need four vectors: position ($\vec{r}$), velocity ($\vec{v}$), acceleration ($\vec{a}_c$) and angular velocity ($\vec{\omega}$).
(a) Which of these four vectors does not change direction with time? (b) what is the rate at which the others rotate? Why?

10. In problem 9 the object of mass 0.5kg is moving clockwise in the xy-plane, makes 30 revolutions per minute and the radius of the orbit is 2m. a) What is the period
b) What is the angular velocity vector
c) At $t=0$, the position vector is along the x-axis [$\vec{r}(0) = 2m\hat{x}$]. Calculate and Draw the velocity and acceleration vectors (d) Calculate

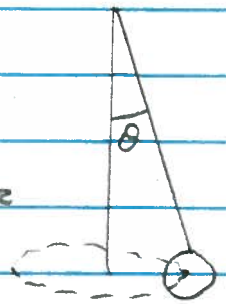
and draw the position, velocity and acceleration vector at $t = 1.75$ secs.

e) What is the centripetal force required for this motion.

11. In prob 11 the centripetal force is provided by a spring. a) Is the spring stretched or squeezed? Why? (b) If the spring constant is 10^4 N/m, what is the change in the length of the spring?

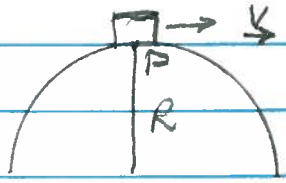
12. You are travelling on a horizontal curvy road where the radius is 20m and the static friction coefficient between tires and road surface is 0.5. What is the maximum speed at which you can negotiate this curve without skidding? Why?

13 Shown is a conical pendulum: A mass of 0.5kg is hanging from the ceiling with a light string. It moves on a horizontal circle of radius 0.05m at 2 revs. per sec. What is the value of the angle θ and the tension in the string? Why?

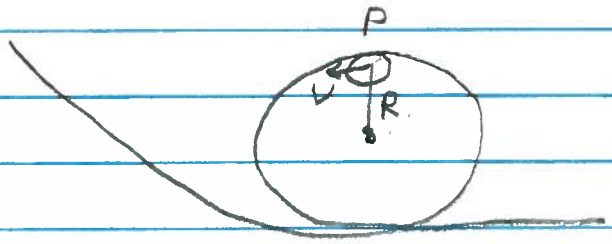


14. In prob 13 if you double the radius by what factor will the angle θ change? Why?

15 Shown is a smooth track where an object is travelling with a velocity $\underset{\rightarrow}{V}$ on a "hill" of radius 2m. What is the maximum value of V if the object does not wish to lose contact at P? Why?

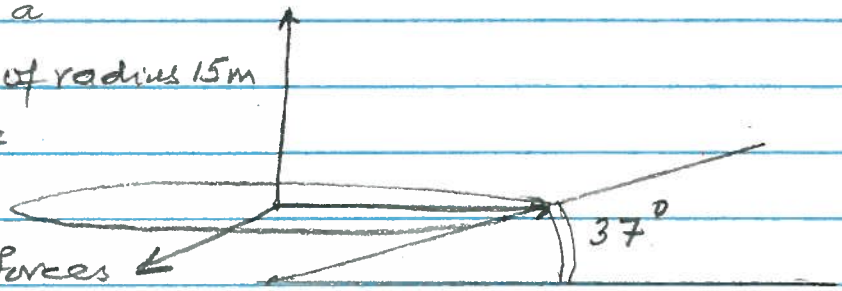


16 In a loop-the-loop the object is constrained to move under a track of radius 5m. What is the minimum value of $\underset{\rightarrow}{V}$ required for the object to go around the loop without falling down? Why?



17 We have been assuming that observers on Earth (either at rest or moving at constant velocities) are Inertial. Do you believe that this is strictly correct? If not, how serious is the error.

18. A car is moving at a constant speed on a horizontal circle of radius 15m a banked curve as shown.



a) What are the forces acting on the car?

b) What is the speed at which car travel without skidding

c) What is the apparent weight of a 50kg passenger at the speed calculated in (b). Justify your answers

19. Newton's law of Gravitation is written as

$$\vec{F}_G = -\frac{GM_1M_2}{r^2}\hat{r}$$

Why is there a "minus" sign on the right side of this equation?

20. A point mass m is located inside a spherical shell of radius R_{shell} & mass M_{shell}. What is the gravitational force on the shell due to m? Why?

21. Considering that the Earth rotates about its axis once every 24 hours locate the points on Earth where your apparent weight is i) maximum, ii) minimum? (Radius of Earth is 6400 km)

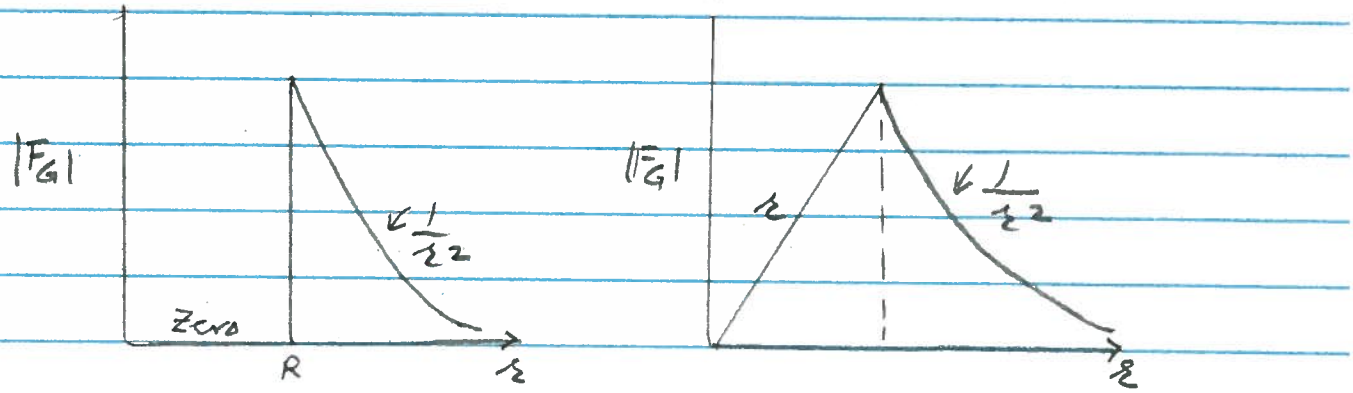
22. Using the results of Prob 21 show that if you increase the angular velocity of the Earth by a factor of about 18, you will become "weightless" at the equator.

23. Assuming that the Earth is a uniform sphere of radius 6400 km and mass 6×10^{24} kg show that the acceleration due to gravity of an object close to the surface is $-9.8 \text{ m/s}^2 \hat{r}$

24. What would your weight be if you were located at the center of the Earth? Why?

25. How far above the Earth would your weight be i) one half, ii) one fourth, iii) one ninth of your weight on Earth's surface? Why?

26. The pictures show $|\vec{F}_G|$ as a function of r, the distance from the center of a sphere, between a spherical mass of radius R and a point mass. Which of the spheres is hollow (shell like)? why?



27 Assuming that planets go around the Sun in circular orbits show that Newton's law of Gravitation leads to Kepler's law

$$T_p^2 = \frac{4\pi^2}{G M_{sun}} R_p^3$$

where T_p = Period of Planet
R_p = Radius of orbit

28 What equation would you write to relate the periods and orbital radii of satellites (including the moon) of Earth? Why?

29. Why are astronauts in stable orbit said to be weightless? (DO NOT SAY THEY ARE IN FREE FALL)

30 On Earth why does a pendulum hang vertically (along $\hat{r}$) only at the poles and at the equator?

31. The moon, which has an orbit of radius 4×10^5 km about the Earth, has a period of about 27 days. Where would you locate a satellite to have a period of about 1 day? Why?

32. Using the Earth-moon distance of problem 31 and knowing that $M_{Earth} \simeq 81 M_{Moon}$ where would you locate an object on the Earth-Moon line so that it experiences no force?

33. A geosynchronous satellite is one whose position relative to some point on Earth is unaltered as a function of time. Where would you locate such a satellite? Why?

34. Keplerian orbits obey $T_p^2 \propto R_p^3$ so as we go further away from the Sun will the orbital speed reduce, increase or stay the same? Justify your answer?