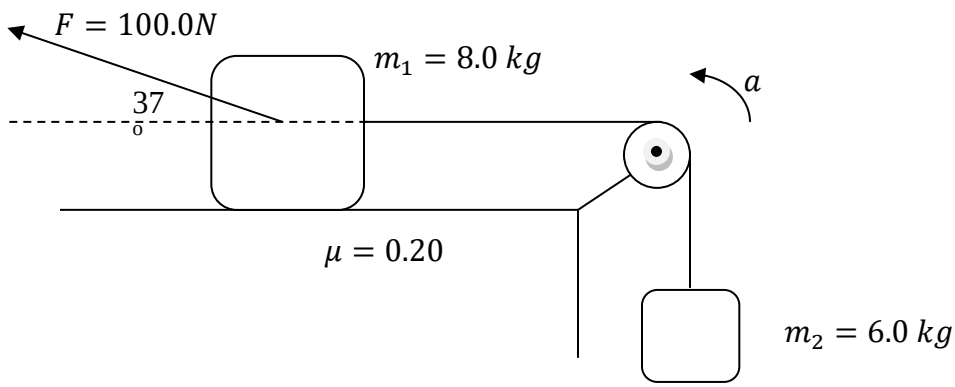
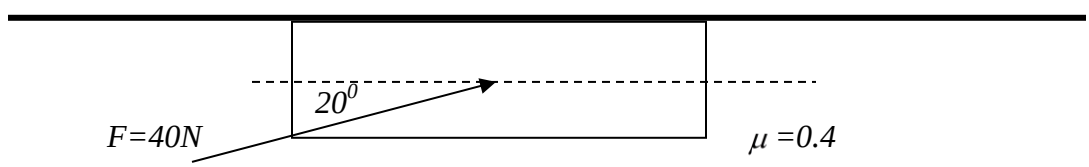
SPH4U – Review Problems

1. Determine the acceleration of the system and the tension in the string. [1.24 m/s/s, 66N]



2. Determine the horizontal acceleration of a 0.5-kg block that is being pushed along the ceiling with a force of 40N at an angle of 20^0 upward to the horizontal. See diagram for the coefficient of friction. [68 m/s/s]



3. A catapult launches a cat from ground level to a target located on the ground. The cat leaves the catapult moving at 100 km/h at an angle of 40^0.
   a) What is the cat's velocity half-way through the trajectory (size and direction)? [21.3 m/s]
   b) What is the cat's velocity at impact (size and direction)? [27.8 m/s [40 below]]
   c) How long is the cat in the air for? [3.64 s]
   d) What is the maximum height? [16.3 m]
   e) What is the range of the cat? [77 m]

4. A projectile is launched at 55^0 with a muzzle velocity of 60 m/s.
   a) What is the maximum height that the projectile reaches? [123 m]
   b) How far horizontally has the object traveled by the time it reaches the maximum height? [173 m]

5. After landing safely on the target the cat tries another projectile apparatus. This time the cat is shot from a cannon over a 30 m high wall. The cat is launched at an angle of 55^0 and can be assumed to be at ground level during launch. With what speed (in km/h) does it have to be launched to make it approximately 5 m over the wall if the wall is 250 m from the cannon? [54 m/s]

6. A plane is flying in a vertical loop of 1500 m radius. At what speed is the plane flying at the top of the loop, if the vertical force exerted by the air on the plane is zero at this point? [121 m/s/s]

7. An object of mass 3.0 kg is whirled around in a vertical circle of radius 1.3 m with a constant velocity of 6.0 m/s. Calculate the maximum and minimum tension in the string. [112N, 53N]

8. A large metal disc is rotating in a horizontal plane at a constant rate. It was measured that 22 revolutions happen in 8 seconds. A dime (mass of 1.75g) is placed on the disc at some distance from the center such that it just stays in place and does not slide off. Calculate this distance. The coefficient of friction is 0.3. [0.01 m]

9. A 1500 kg car safely turns (without slipping) on a corner banked at 30° to the horizontal moving at 27 m/s. Calculate the radius of the turn if the coefficient of friction between the tires and the road is 0.2. Include a FBD. If the bank angle changed to 50°, calculate how fast they could negotiate the same turn without slipping. [?]

10. A golf club exerts an average net force of 7200 N on a ball for the 0.0005 s they are in contact.
    a) Calculate the impulse of the impact on the ball. [3.6 Ns]
    b) If the ball has a mass of 45 g, what velocity will it have as it leaves the club face? [80 m/s]

11. A puck (m = 0.115 kg) slides along frictionless ice at 16 m/s. It encounters a rough patch of ice that is 3 m in distance and slows down to a speed of 12 m/s. Calculate the change in momentum as well as the time it takes to travel through the rough patch and the average force acting on the puck. [2.2 N]

12. A 5000 kg boxcar moving at 5.2 m/s on a level, frictionless track, runs into a stationary 8000 kg tank car.
    a. If they hook together during the collision, how fast will they be moving afterwards? [2 m/s]
    b. If the collision is somehow completely elastic determine the speeds of the two cars after the collisions.

13. A 2000 kg car travelling east at 24 m/s enters an icy intersection and collides with a 3600 kg truck travelling at 10 m/s [S20^{0}W]. If they become coupled together in the collision, what is their velocity immediately after impact (size and direction)? [8.8 m/s [44°]]

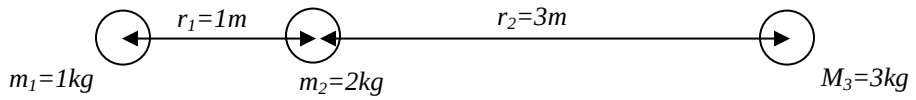
14. An ideal spring is compressed 15 cm on a horizontal surface. When released, it accelerates a block (5-g) along the frictionless surface. The block leaves the spring launcher and then travels up a long ramp and stops when it reaches a height of 0.54 m. What is spring constant of the spring? [2.4 N/m]

15. The equilibrium position for an ideal spring, with a spring constant of 400 N/m, that is attached to a wall is 1.3 m. A force of 2000 N is applied to the spring. What is the new position of the end of the spring? [6.3 m]

16. Two spheres exert a gravitational force of 2.0×10^{-8} N on each other. Calculate the separation of the two spheres if one is 40kg and the other is 20kg. [1.63 m]

17. Find the acceleration of a falling object on Mars, given that the radius of Mars is one-half that of Earth and the mass of Mars is one-eighth that of Earth. [4.89 m/s/s]

18. Three masses are placed in a straight line. Find the force acting on the second mass as exerted by the other two. [8.89×10^{-11} N Right]



19. Two sources are vibrating in phase, and set up waves in a ripple tank. A point P on the second nodal line is 12.0 cm from source A and 20.0 cm from source B. When the sources are started, it takes 2.0 s for the first wave to reach the edge of the tank, 30 cm from the source. Find the velocity, wavelength and frequency of the wave. [2.8 Hz]

20. A point on the seventh nodal line in a pattern using a wavelength of 2.0 cm was found to be 8.0 cm from the center line (central maximum). If the distance between the sources was 19.5 cm, how far out from the midpoint of the source line was the point? At what angle is this minimum found? [12 cm, 42°]

21. In an interference experiment, red light with a wavelength of $6.0 \times 10^{-7} m$ passes through a double slit. On a screen 1.5 m away, the distance between the 1st and 11th dark bands is 2.0 cm.
    a) What was the separation of the slits? [4.5×10^{-4} m]
    b) What would the spacing be, between adjacent nodal lines, if blue light were used? ($\lambda_{blue} = 4.5 \times 10^{-7} m$) [1.5×10^{-3} m]

22. A camera lens (*n=1.52*) is coated with a film of magnesium fluoride (*n=1.25*). What should the least thickness of the film be to minimize reflected light with a wavelength of 550 nm?

23. A group of cosmic tourists rockets away from Earth at 0.7c toward another distant planet. You measure that it takes them 2 years to get to the new planet. a) For the people on the ship, how much time do they measure has passed? b) Calculate the proper distance and the relativistic distance between Earth and the new planet. [1.43 years, proper: 1.32×10^{16}, rel: 9.5×10^{15}]

24. A person has a mass of *75 kg*. What mass would they have, relative to a person watching them fly by, if they could travel at 2×10^{8} m/s? [100 kg]

25. An apple of mass, 0.5 kg, spontaneously annihilates itself and changes into energy. How much energy would the explosive apple yield? [4.5×10^{16} J]

26. A spaceship goes past a planet at a speed of 0.80*c*. An observer on the planet measures the length of the moving spaceship as 40 m. He also says that his planet has a diameter of 2.0×10^{6}m.
    a) How long does the woman on the spaceship measure the ship to be? [67m]
    b) Calculate the diameter of the planet relative to the woman in the ship? [1.2×10^{6} m]

c) According to the man on the planet, the spaceship takes 8.0 s to reach the next planet in his solar system. How long would the woman on the spaceship say it took? [4.8s]

27. What is the energy, in electron volts, required to give an electron an associated de Broglie wavelength of 0.15 nm (the mass of an electron is 9.11×10^{-31}kg)? [67 eV]

28. Barium has a work function of 2.48 *eV*. What is the maximum kinetic energy of the ejected electrons if the metal is illuminated by light with a wavelength of 450 nm? [0.28eV]

29. Find the minimum frequency of the light required to eject photoelectrons from a metallic surface whose work function is 7.2×10^{-19} *J*. *[Ans: 1.1×10^{15} Hz]*

30. When light of wavelength *482 nm* falls onto a certain metallic surface, a retarding potential of *1.2 V* proves just sufficient to make the current passing through the phototube fall to zero. Calculate the work function of the metal. *[Ans: 1.38 eV]*

31. a) Calculate the momentum of a photon of wavelength 2.50×10^{-9} m. [*Ans: 2.65×10^{-25} kg m/s]*

    b) Calculate the speed of the electron having the same momentum as the photon in a). (m_e = *9.11×10^{-31} kg*). *[Ans: 2.91×10^{5} m/s]*

    c) Calculate the kinetic energy of the electron. How does it compare with the energy of the photon? *[Ans: $E_{K\ electron} = 3.86 \times 10^{-20}$ J, $E_{photon} = 7.96 \times 10^{-17}$J]*

32. **<u>Fission</u>** is the process by which a large atom is split apart using one or more neutrons. One process is characterized by the following reaction. Large amounts of energy are liberated from this type of reaction because the mass of the products is less than the mass of the reactants. **Problem:** determine the amount of energy (in *MeV*) liberated from the reaction of 2-kg of Uranium - 235. (A_N=6.023×10^{23} atoms/mol).

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{134}_{54}Xe + ^{100}_{38}Sr + 2\,^{1}_{0}n$$

^{134}Xe [133.905u] and ^{100}Sr [99.9803u]

33. **<u>Fusion</u>** is the process by which two very light atoms are fused ("stuck") together. A typical reaction is one in which deuterium and tritium reacts to form helium and a neutron. This is the process occurring in the Sun. **Problem:** Write the reaction. How much energy is liberated from this reaction? Where does the energy come from? Compare the amount of energy liberated from this type of reaction to the amount liberated from the fission reaction in the question above.