SPH4U Exam Review Problems

Kinematics

1. Kyle is in his car traveling at a constant speed of 150 km/h down the road. He passes a police car that was stationary at the side of the road. He sees the radar reading and immediately begins accelerating (8 m/s/s) in order to catch the delinquent teenager. How long and how far down the road does he catch Kyle?

2. A train is travelling at 23 m/s [E] when it enters a curved portion of the track and experiences an average acceleration of 0.14 m/s^2 [S] for 95 s. Determine the velocity of the trains after this acceleration.

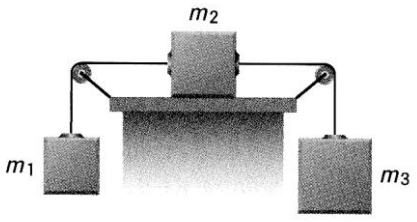
Projectile Motion

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 40º.
   a) What is the cat's velocity half-way through the trajectory (size and direction)?
   b) What is the cat's velocity at impact (size and direction)?
   c) How long is the cat in the air for?
   d) What is the maximum height?
   e) What is the range of the cat?

4. After landing safely on the target the cat tries another projectile apparatus. This time the cat is shot out of a cannon over a 30 m high wall. The cat is launched at an angle of 55º0 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?

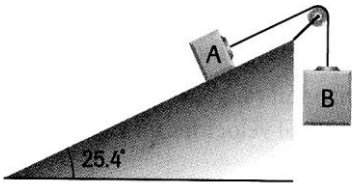
Dynamics

5. Three blocks of masses m_1=26kg, m_2=38kg, and m_3=41kg, are connected by two strings over two pulleys as shown in the figure.
   a) Determine the acceleration of the blocks.
   b) Determine the tension in each of the strings.



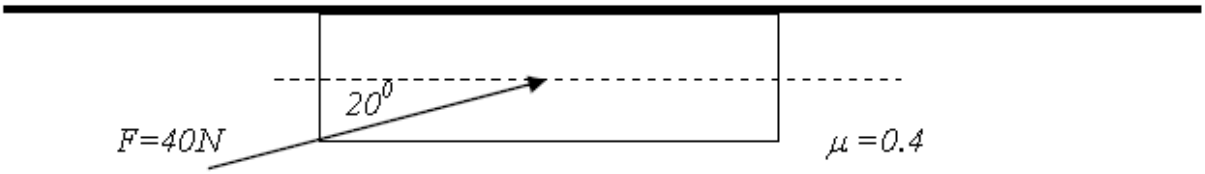
6. A skier on a slope inclined at 4.7º to the horizontal pushes on ski poles and starts down the slope. The initial speed is 2.7 m/s. The coefficient of kinetic friction between skis and snow is 0.11. Determine how far the skier will slide before coming to rest.

7. Box A (m=2.5 kg) is connected by a rope that passes over a frictionless pulley to Box B (m=5.5 kg), as shown in figure. The coefficient of kinetic friction between box and ramp is 0.54.



Determine the acceleration of the boxes.

8. 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 20º upward to the horizontal. See diagram for the coefficient of friction.



Circular Motion

9. 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?

10. 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.

Work & Energy

11. A 1.2×10^3 kg space probe, travelling initially at a speed of 9.5×10^3 m/s through deep space, fires its engines that produce a force of magnitude 9.2×10^4 N over a distance of 86 km. Determine the final speed of the probe.

12. A 73 kg skier coasts up a hill inclined at 9.3º to the horizontal. Friction is negligible. Use the work-energy theorem to determine how far along the hill the skier slides before stopping, if the initial speed at the bottom is 4.2 m/s.

13. 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?

Momentum & Collisions

14. 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?
    b) If the collision is somehow completely elastic determine the speeds of the two cars after the collisions.

15. 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 [S20ºW]. If they become coupled together in the collision, what is their velocity immediately after impact (size and direction)?

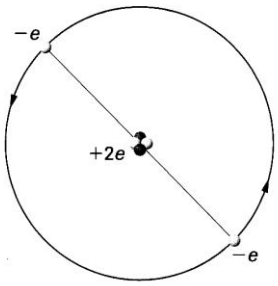
Motion in Space

16. Tethys, one of Saturn's moons, travels in a circular orbit at a speed of 1.1×10^4 m/s. The mass of Saturn is 5.67×10^{26} kg. Calculate
    a) the orbital radius in kilometres.
    b) the orbital period in Earth days.

17. A neutron star results from the death of a star about 10 times as massive as the Sun. Composed of tightly packed neutrons, it is small and extremely dense.
    a) Determine the escape speed from a neutron star of diameter 17 km and mass 3.4×10^{30} kg.
    b) Express your answer as a percentage of the speed of light.

Electric Fields & Forces

18. The figure represents a neutral He atom with two electrons on either side of the nucleus, in a well-defined circular orbit of radius 2.64×10^{-11} m. Calculate the magnitude and direction of the electric force on each electron.



19. An electron enters a parallel plate apparatus 10.0 cm long and 2.0 cm wide, moving horizontally at 8.0×10^7 m/s, as in figure. Calculate
    a) the vertical deflection of the electron from the original path,
    b) the velocity with which the electron leaves the parallel plate apparatus.

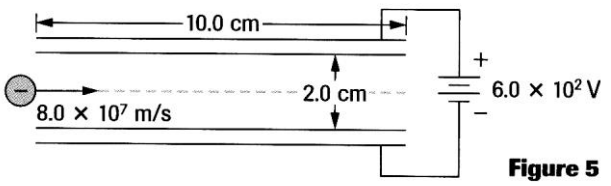


Figure 5

Magnetic Fields & Forces

20. An α particle of charge $+3.2 \times 10^{-19}$ C and mass 6.7×10^{-27} kg first accelerates through a potential difference of 1.2×10^{3} V, then enters a uniform magnetic field of magnitude 0.25 T at 90º. Calculate the magnetic force on the particle.

Wave Nature of Light

21. 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.

22. In an interference experiment, red light with a wavelength 6.0×10^{-7}m of 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?
    b) What would the spacing be, between adjacent nodal lines, if blue light were used? ($\lambda_{blue} = 4.5 \times 10^{-7}$m)

Special Relativity

23. A spaceship goes past a planet at a speed of 0.80c. 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?
    b) What does the woman on the spaceship measure the diameter of the planet to be?
    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?

SPH4U Exam Review Problem Answers

1. 10s, 435m
2. 27 m/s [E30ºS]
3. 21.3 m/s[horiz], 27.8 m/s [E40S], 3.64s, 16.3 m, 77.6 m
4. 54 m/s (doesn't go over wall at peak of trajectory)
5. 1.4 m/s^2 [right], 2.9×10^{2} N, 3.4×10^{2} N
6. 13.7 m
7. 3.8 m/s^2 [right]
8. 68 m/s^2 [right]
9. 120 m/s
10. 54 N, 113 N
11. 1.0×10^{4} m/s
12. 5.6 m
13. 2.35 N/m
14. 2.0 m/s [forward], 1.2 m/s [backward] and 4.0 m/s [forward]
15. 8.8 m/s [E43ºS]
16. 3.1×10^{5} km, 2.0 days
17. 2.3×10^{8} m/s, 77% of c
18. 5.8×10^{-7} N towards nucleus
19. 0.41 cm, 8.0×10^{7} m/s [4.7º up from horizontal]
20. 2.7×10^{-14} N
21. 0.15 m/s, 0.053 m, 0.36 Hz
22. 0.00045 m, 0.0015m
23. 67 m, 1.2×10^{6} m, 4.8 s