

15 – 20 Multiple Choices & 1 problem solving from each unit & Communication

Communication:

1. Use $Ft = mv_f - mv_i$ (the product of force and time equals to the change of momentum) to explain the situations such as egg drop challenge, ride the punch in boxing, helmet, etc.
2. Describe differences and similarities between electric field, gravitational field, and magnetic field.
3. Describe how does 1) Cyclotron 2) mass spectrometer, 3) Milliken oil droplet experiment work.

Problem Solving:

Unit 1: Kinematics and dynamics

- 5 key equations
- Projectile motion
- Circular motion
- Newton's law
- Pulley question, breakdown force component
- Static and kinetic friction
- No adding displacement in 2D, or change of velocity (acceleration) in 2D
- No p-t, v-t, a-t graph

Unit 2: Energy and momentum

- Conservation of energy: $E_{gi} + E_{ki} + E_{ei} + W_{loss} = E_{gf} + E_{kf} + E_{ef}$
- Elastic and inelastic collision, conservation of momentum
- Collision in 2D

Unit 3: Gravitational, electric, magnetic field

- Universal law of gravitation
- Orbiting velocity of satellite in orbit
- No change in gravitational potential energy in universe, no "4 cases", no escape velocity
- Electric force, electric field, and electric potential in parallel plate and due to point charge
- In parallel plate, $\Delta E_k = -\Delta E_e$
- Calculate "N" and describe Milliken oil droplet experiment
- 3 Right hand rule
- Lenz's law
- Magnetic force in current carrying wire and charged particle, $F = qvB$ and $F = ILB$

Unit 4: Light

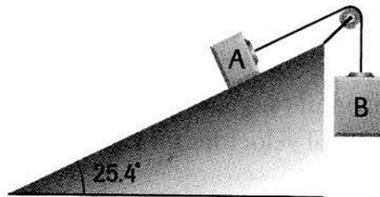
- Refraction
- Snell's law
- Total internal reflection and critical angle
- Diffraction of waves: waves of longer wavelength are diffracted by a larger amount
- Significant diffraction occurs when width of opening $<$ water wavelength
- Interference of water wave: $|P_n S_1 - P_n S_2| = (n - \frac{1}{2})\lambda$
- Double slits experiment: $\frac{x_n}{L} = (n - \frac{1}{2})\frac{\lambda}{d}$ and $\frac{\Delta x}{L} = \frac{\lambda}{d}$

Projectile Motion

- 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° .
 - What is the cat's velocity half-way through the trajectory (size and direction)?
 - What is the cat's velocity at impact (size and direction)?
 - How long is the cat in the air for?
 - What is the maximum height?
 - What is the range of the cat?
- 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 55° 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

- 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.



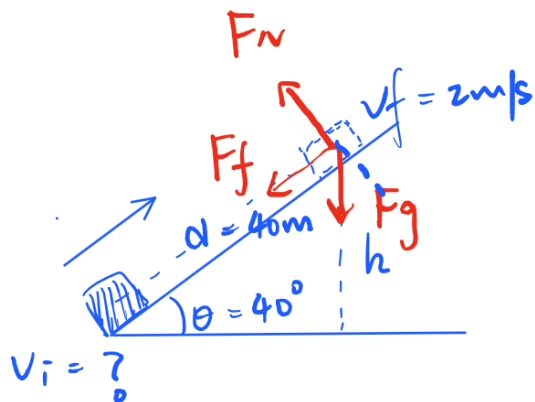
Determine the acceleration of the boxes.

Circular Motion

- 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?
- 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.

Energy

A block with an unknown initial velocity goes up a ramp and when $d = 40\text{m}$, its $v_f = 2\text{m/s}$. Given $\mu = 0.35$, the angle of the ramp is 40° . Determine $v_i = ?$



Example 3: A block with a mass of 2.0 kg is held against a spring with spring constant 250 N/m . The block compresses the spring 22 cm from its equilibrium position. After the block is released, it travels along a frictionless surface and then up a frictionless ramp. The ramp's angle of inclination is 30° . Determine how far along the ramp the block will travel before it stops.



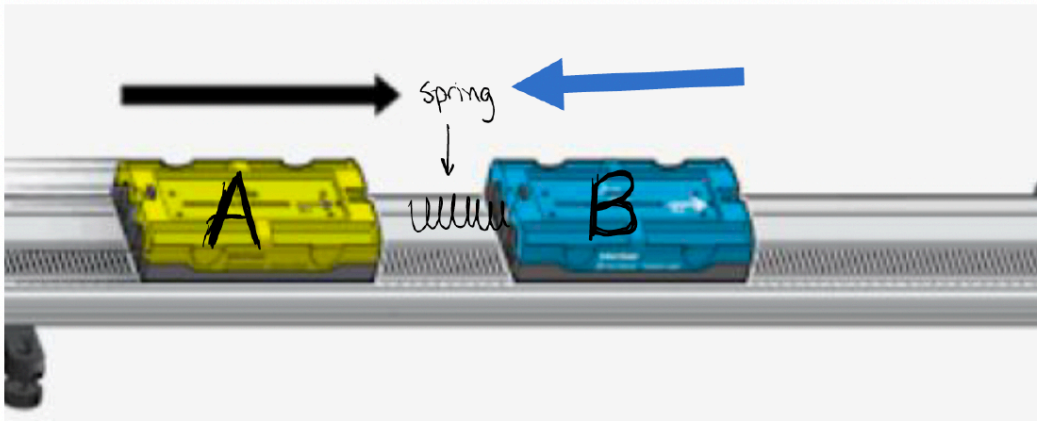
What if the surface has friction and the block takes 0.55 m to become completely stopped. What is the coefficient of kinetic friction?

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 [$S20^\circ W$]. If they become coupled together in the collision, what is their velocity immediately after impact (size and direction)?

Cart A ($m_A = 850 \text{ g}$) has a velocity of 4 m/s [right] and is moving along a frictionless surface towards cart B ($m_B = 450 \text{ g}$), which is moving at 1.0 m/s [left]. Attached to cart B is a long spring, oriented horizontally, as shown in the diagram below. The spring has a spring constant of 1.2 kN/m .



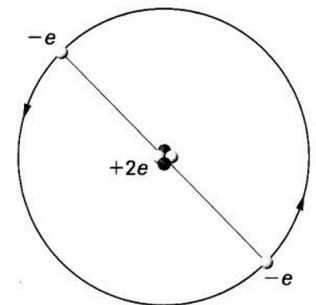
- What is the amount by which the spring is compressed when the separation of the carts is at a minimum?
- What is the speed of each cart after the collision?

Motion in Space

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

Electric Fields & Forces

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



- An electron enters a parallel plate apparatus 10.0 cm long and 2.0 cm wide, moving horizontally at $8.0 \times 10^7 \text{ m/s}$, as in figure. Calculate
 - the vertical deflection of the electron from the original path,
 - the velocity with which the electron leaves the parallel plate apparatus.

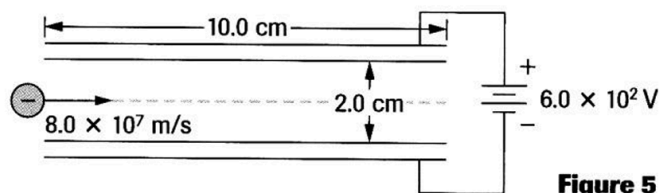


Figure 5

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? ($\lambda_{\text{blue}} = 4.5 \times 10^{-7}$ m)

Answer key:

- | | |
|--|---|
| 1. 10s, 435m | 12. 5.6 m |
| 2. 27 m/s [E30°S] | 13. 2.35 N/m |
| 3. 21.3 m/s[horiz], 27.8 m/s [E40S], 3.64s, 16.3 m, 77.6 m | 14. 2.0 m/s [forward], 1.2 m/s [backward] and 4.0 m/s [forward] |
| 4. 54 m/s (doesn't go over wall at peak of trajectory) | 15. 8.8 m/s [E43°S] |
| 5. 1.4 m/s^2 [right], 2.9×10^2 N, 3.4×10^2 N | 16. 3.1×10^5 km, 2.0 days |
| 6. 13.7 m | 17. 2.3×10^8 m/s, 77% of c |
| 7. 3.8 m/s^2 [right] | 18. 5.8×10^{-7} N towards nucleus |
| 8. 68 m/s^2 [right] | 19. 0.41 cm, 8.0×10^7 m/s [4.7° up from horizontal] |
| 9. 120 m/s | 20. 2.7×10^{-14} N |
| 10. 54 N, 113 N | 21. 0.15 m/s, 0.053 m, 0.36 Hz |
| 11. 1.0×10^4 m/s | 22. 0.00045 m, 0.0015m |
| | 23. 67 m, 1.2×10^6 m, 4.8 s |