Key

AP Physics Fall Semester Review Questions

This is an opportunity to see how much you know or remember about what we've covered so far in Physics. This is not graded, and the answers are on my website hut-lhansen.weebly.com. You may use this on the final.

Unit 1: Measurement

1. What is the density of an object with a mass of 24.5 kg and a volume of 19.5 L – in g/ml?

$\rho = \frac{m}{V} = \frac{24{,}500\,g}{19{,}500\,mL} = 1.25\,\frac{g}{mL}$

2. How many significant figures are in the following three numbers:

10,800 kg — 3

0.053 N — 2

1.03 E 5 m — 3

3. Make the following conversions:

2.5 kg to mg: $2.5\,kg \times \frac{1000\,g}{kg} = 2{,}500\,g$

5.1 m to mm: $5.1\,m \times \frac{1000\,mm}{1\,m} = 5{,}100\,mm$

3.8 km/h to m/s: $\frac{3.8\,km}{h} \times \frac{1000\,m}{1\,km} \times \frac{1\,h}{3600\,s} =$

4. Perform the following operations, and round to the correct number of significant figures:

12.2 m • 4.8 cm: $= 0.048\,m$; $0.59\,m^2$

13.8 kg / 4 mL: $3\,\frac{kg}{mL}$

Unit 2: One Dimensional Kinematics

1. What is the acceleration of a car that stops in 36 meters and has an initial velocity of 24.5 m/s?

$X_0 = 0\,m$ $V_0 = 24.5\,m/s$

$X = 36\,m$ $V = 0\,m/s$

$V^2 = V_0^2 + 2a(X - X_0)$

$\frac{V^2 - V_0^2}{2(X - X_0)} = a = \frac{0^2 - (24.5\,m/s)^2}{2(36\,m - 0\,m)} = -0.34\,m/s$

2. A firework manufacturing company makes mortar shells that are fired straight up in the air. If they are designed to detonate exactly at the apex of their flight, 5.00 seconds after launching, what is the velocity of launch? Neglect air resistance.

$V = V_0 - gt = -9.81 \cdot 5.0\,s = -49.1\,m/s$

$V_{launch} = 49.1\,m/s$

$V_0 = ?$ $g = 9.81\,m/s$ use velocity eq.

$V = 0\,m/s$

$t = 5.0\,s$

assume object starts at top of arc & falls to earth in 5.00 s ⇒ at impact, it's velocity will equal the velocity of launch

3. A bus accelerates from rest at a constant rate of 1.5 m/s² for 5.0 s. What is the velocity of the bus after that time?

$V_0 = 0.0\,m/s$ $a = 1.5\,m/s^2$ $t = 5.0\,s$ $V = ?$

$V = V_0 + at = 1.5\,m/s^2 \cdot 5.0\,s = 7.5\,m/s$

4. How far did the bus from the previous problem travel in 10.0 seconds?

$X_0 = 0\,m$ $X = X_0 + V_0 t + \frac{1}{2}at^2$

$= 0 + 0 + \frac{1}{2} \cdot 1.5\,m/s^2 \cdot (10.0\,s)^2 = 75\,m$

5. What is the velocity of a dropped object that falls for 5.8 seconds before hitting the ground?

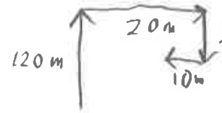
$V = V_0 - gt = -(9.81\,m/s) \cdot 5.8\,s = -57\,m/s$

6. For the previous problem, how far did the object fall before hitting the ground?

$Y = Y_0 + V_{Y_0} t - \frac{1}{2} g t^2 = 0 + 0 - \frac{1}{2}\,9.81\,m/s^2 \cdot (5.8\,s)^2 = 170\,m$

Unit 3: Motion and Two Dimensional Kinematics

1. A student walks 120.0 m north, then 20.0 m east, then 30.0 m south, then 10.0 m west. What is his resultant displacement (distance AND direction)?



$\Delta x = 20\,m - 10\,m = 10\,m$

$\Delta y = 120\,m - 30\,m = 90\,m$

$d = \sqrt{x^2 + y^2} = \sqrt{(10\,m)^2 + (90\,m)^2} = 90.6\,m$

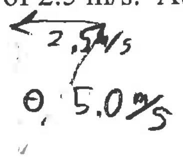
$\theta = \tan^{-1}\left(\frac{90}{10}\right) = 83.7°$

2. A person drags a sled along the ground, and the tow rope has an angle of 30.0°. If the tension on the rope is 87 N, what are the horizontal and vertical components of the force he exerts?

$F_x = 87N \cdot \cos 30° = 75.3\,N$

$F_y = 87N \cdot \sin 30° = 43.5\,N$

3. A motorboat's speed in still water is 5.0 m/s. The driver wants to go directly across a river with a current of 2.5 m/s. At what angle upstream should the boat be steered?



$\theta = \sin^{-1}\left(\frac{2.5\,m/s}{5.0\,m/s}\right) = 30.°$

4. How far will a cannonball travel if it is launched on level ground at an angle of 65.0° with an initial velocity of 150. m/s? Assume that there is no air resistance.

$$Range = \frac{V_0^2 \cdot \sin(2\theta)}{g} = \frac{(150\,m/s)^2 \sin(2 \cdot 65.0°)}{9.81\,m/s^2} = 1760\,m$$

5. For the previous problem, what are the initial vertical and horizontal components of velocity?

$V_y = V_0 \sin\theta = 150.\,m/s \cdot \sin 65° = 136\,m/s$

$V_x = V_0 \cos\theta = 150.\,m/s \cdot \cos 65° = 63.4\,m/s$

Unit 4: Dynamics (Forces)

1. A 25.0 N net force is applied to a 2.3 kg mass. What is the object's acceleration?

$F = m \cdot a \quad a = \frac{F}{m} = \frac{25.0\,N}{2.3\,kg} = 11\,m/s^2$

A force acts on a 4.5 kg mass, giving it an acceleration of 3.0 m/s^2.

2. What is the magnitude of the force?

$F = m \cdot a = 4.5\,kg \cdot 3.0\,m/s^2 = 14\,N$

3. If the same force acts upon a 1.5 kg mass, what acceleration results?

$a = \frac{F}{m} = \frac{14\,N}{1.5\,kg} = 9.3\,m/s$

4. A 72 kg male skater pushes a 45 kg female skater, causing her to accelerate at a rate of 2.0 m/s^2. At what rate will the male skater accelerate?

Female Force:
$F = 45kg \cdot 2.0 m/s^2 = 90. N$

$F_{male} = F_{female}$
$90.N = 90.N$

Male
$a = \frac{F}{m} = \frac{90.N}{72kg} = 1.25 m/s^2$

5. A 40.0 kg crate is at rest on a level surface. If the coefficient of static friction between the crate and the surface is 0.69, what horizontal force is required to get the crate moving?

$F_s = \mu_s \cdot m \cdot g$
$= 0.69 \cdot 40.0kg \cdot 9.81 m/s^2 = 270N$

6. For the previous problem, if the same force is used to keep pushing the crate, what will its acceleration be if the coefficient of kinetic friction between the crate and the ground is 0.48?

$F_K = 0.48 \cdot 40.0kg \cdot 9.81 m/s^2$ 190N

$F_{net} = 270_N - 190_N = 80N$

$a = \frac{F_{net}}{m} = \frac{80N}{40.0kg} = 2.0 m/s$

Unit 5: Circular Motion and Gravitation

1. In winding a rope up, a pulley with a radius of 15 cm turns 5 complete rotations. How much rope was wound up?

$\theta = 5 \text{ rotations} \times \frac{2\pi \text{ rad}}{\text{rotation}} = 10\pi \text{ rad}$

$\theta = \frac{s}{r}$

$s = \theta \cdot r$

$s = 10\pi \text{ rad} \cdot 15cm = 470cm = 4.7 m$

2. How much of an angle does a rotating wheel (radius 0.88 m) move in 13.8 rotations?

$13.8 \text{ rotations} \times \frac{2\pi \text{ rad}}{\text{rotations}} = 86.7 \text{ radians}$

3. The driver of a car sets the cruise control and ties the steering wheel so that the car travels at a uniform speed of 11 m/s in a circle of diameter 80 m. What angular distance does the car move in 2.00 minutes?

$\theta = \frac{s}{r} = \frac{1320m}{40m} = 33 rad$

$t = 120s$ $r = 40m$

$V_t = 11 m/s$ $s = V_t \cdot t = 11 m/s \cdot 120s = 1320m$

4. For the previous problem, what arc length does the car travel during the 2.00 minutes?

$s = V_t \cdot t = 11 m/s \cdot 120s = 1320m$

600. Kg

5. A car with a constant speed of 20.5 m/s enters a circular flat curve with a radius of curvature of 0.30 km. What force of friction do the tires have to supply so the car doesn't slip off the road?

$V_t = 20.5 m/s$ $m = 600.kg$ $f_K = F_c = \frac{m \cdot V_t^2}{r} = \frac{600.kg \cdot (20.5 m/s)^2}{150m} = 1681N$

$r = 150m$

6. Two objects are attracted to each other with a certain gravitational force. If the original force between the objects is 1.0 N and the distance is doubled, what is the new gravitational force between the objects?

$F_g \propto \frac{1}{r^2}$ $1.0N \cdot \frac{1}{4} = \frac{1}{4}N$

$\rightarrow 5.3\,E\,11\,m$

7. Two objects with masses of 2.9 E 14 kg and 7.8 E 16 are 5.3 E 8 km apart. What is their gravitational attractive force?

$$F_g = \frac{G \cdot m_1 \cdot m_2}{r^2} = \frac{6.67\,E{-11}\,\frac{N \cdot m^2}{kg^2} \cdot 2.9\,E14\,kg \cdot 7.8\,E16\,kg}{(5.3\,E11\,m)^2} = 5.4E{-3}\,N$$

$\rightarrow 2.1\,E\,12\,m$

8. How long is the period of an asteroid around our sun at a distance of 2.1 E 9 km from the sun?

$$T^2 = K \cdot r^3$$

$$T = \sqrt{K \cdot r^3} = \sqrt{2.97E{-19}\,s^2/m^3 \cdot (2.1E\,12\,m)^3} = 1.65E9\,s \times \frac{1h}{3600s} \times \frac{1d}{24h} \times \frac{1y}{365d} = 52 \text{ years}$$

9. A brass sphere (mass 1.2 kg) on the end of a rope swings in a circle with a radius of 1.8 m. If the tension on the rope can't excel (exceed) 25 N, what is the maximum speed at which the sphere can rotate?

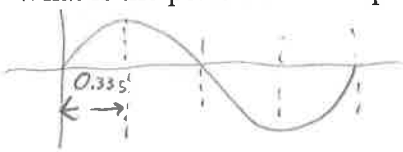
$$F_T = F_c = 25N$$

$$F_c = \frac{m \cdot V_t^2}{r}$$

$$V_t = \sqrt{\frac{F_c \cdot r}{m}} = \sqrt{\frac{25N \cdot 1.8m}{1.2kg}} = 6.1\,m/s$$

Unit 6: Simple Harmonic Motion

1. The time it takes a particle in SHM to travel from the equilibrium position to the first maxima is 0.33 seconds. What is the period of a complete oscillation?



$$0.33s \times 4 = 1.32s$$

2. How far would a spring be compressed (k = 14.3 N/m) if a 2.5 kg mass were placed on it?

$$F_g = 2.5\,kg \times 9.81\,m/s^2 = 24.5\,N \qquad F_s = kx$$

$$x = \frac{F_s}{k} = \frac{24.5N}{14.3\,N/m} = 1.7\,m$$

3. An object of mass 0.45 kg is attached to a spring with spring constant 12.0 N/m. If the object is pulled down 0.25 m from the equilibrium position and released, what is its maximum speed?

$A = 0.25m$
$m = 0.45m$
$K = 12.0\,N/m$

$$V_{max} = \sqrt{\frac{K}{m}}\,A = \sqrt{\frac{12.0\,N/m}{0.45\,kg}} \cdot 0.25m = 1.2\,m/s$$

4. If the frequency of a mass-spring system is 3.50 Hz and the mass on the spring is 3.00 kg, what is the spring constant? $f = 3.50\,Hz$, $m = 3.00\,kg$

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

$$m \cdot (2\pi \cdot f)^2 = K = 3.00kg \cdot (2\pi \cdot 3.5Hz)^2 = 1450\,N/m$$

5. How much energy is possessed by a mass-spring system with a mass of 12 kg, and a spring constant of 3.5 N/m, if it is drawn back 11 cm?

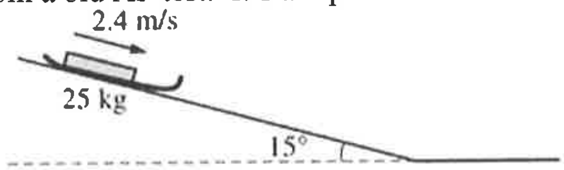
$$E = \tfrac{1}{2}KA^2 = \tfrac{1}{2} \cdot 3.5\,\tfrac{N}{m} \cdot 0.11m = 0.19\,J$$

6. A kid rides on a swing that's 2.3 meters long. What is the period of the swing?

$$T = \sqrt{\frac{L}{g}} \cdot 2\pi = 2\pi \cdot \sqrt{\frac{2.3m}{9.81\,m/s^2}} = 3.0\,s$$

AP Test Problem

This problem is taken from a old AP test. It's a representation of what you could expect in May.



1. (15 points)

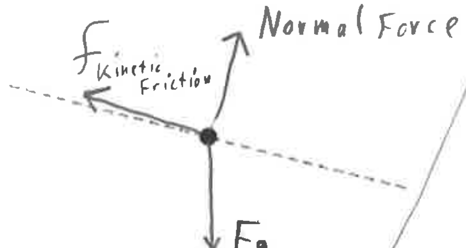
An empty sled of mass 25 kg slides down a muddy hill with a constant speed of 2.4 m/s. The slope of the hill is inclined at an angle of 15° with the horizontal as shown in the figure above.

$X = 21\,m$ $\quad V_0 = 2.4\,m/s$ $\quad$ Position Eq: $\quad t = \frac{X}{V_0} = \frac{21\,m}{2.4\,m/s}$

$X_0 = 0\,m$

(a) Calculate the time it takes the sled to go 21 m down the slope. $X = X_0 + V_0 \cdot t$ ($X_0 = 0\,m$) $\quad$ $= 8.8\,s$

(b) On the dot below that represents the sled, draw and label a free-body diagram for the sled as it slides down the slope.



$f_K = F_{g(x)}$

$= m \cdot g \cdot \sin\theta$

$= 25\,kg \cdot 9.81\,m/s^2 \cdot \sin 15°$

$= 63.5\,N$

(c) Calculate the frictional force on the sled as it slides down the slope. $f_K = \mu_K \cdot N = \mu_K \cdot \cos\theta \cdot m \cdot g$

(d) Calculate the coefficient of friction between the sled and the muddy surface of the slope. $\mu_K = \frac{f_K}{\cos\theta \cdot m \cdot g} = \frac{63.5\,N}{\cos 15 \cdot 25\,kg \cdot 9.81\,m/s^2}$ $= 0.27$

(e) The sled reaches the bottom of the slope and continues on the horizontal ground. Assume the same coefficient of friction.

i. In terms of velocity and acceleration, describe the motion of the sled as it travels on the horizontal ground.

Sled has constant negative acceleration, and slows to a stop after some time.

($F_{net} = \mu_K \cdot N = \mu_K \cdot m \cdot g = 0.27 \cdot 25\,kg \cdot 9.81\,m/s^2 = 66.2\,N$ $\quad a = \frac{F}{m} = \frac{66.2\,N}{25\,kg} = 2.6\,m/s$ $\quad V = V_0 + a \cdot t$ $\quad t = \frac{V - V_0}{a} = \frac{-2.4\,m/s}{-2.6\,m/s} = 0.92\,s$)

ii. On the axes below, sketch a graph of speed v versus time t for the sled. Include both the sled's travel down the slope and across the horizontal ground. Clearly indicate with the symbol t_ℓ the time at which the sled leaves the slope.