Algebra-Based Physics-1: Midterm 1

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October 11, 2024

# 1 Unit 0: Estimation, Unit Analysis, Vectors, and Kinematics I

1. Which of the following represents the density of lead?

- A: 0.11 g $cm^{-3}$
- B: 1.10 g $cm^{-3}$
- C: 11.0 g $cm^{-3}$
- D: 111 g $cm^{-3}$

2. A train leaves Los Angeles Union Station for the Bay Area (Emoryville) at 60 km/hr. If the destination is 600 km to the North, how long before the train reaches the destination?

- A: 0.50 hours
- B: 5.00 hours
- C: 10.0 hours
- D: 24.0 hours

3. What is 25 m $s^{-1}$ in km $hr^{-1}$?

- A: 15 km $hr^{-1}$
- B: 25 km $hr^{-1}$
- C: 60 km $hr^{-1}$
- D: 90 km $hr^{-1}$

4. Suppose a ship accelerates from 0 km hr−1 to 10 km hr−1

in 60 seconds. What is the acceleration?

• A: 60 km hr−1

s

−1

• B: 6 km hr−1

s

−1

• C: 1/6 km hr−1

s

−1

• D: 1/60 km hr−1

s

−1

5. Estimate the area of the North Quad of Whittier College (the open space outside the SLC):

• A: 5000 m2

• B: 5000 cm2

• C: 500 m2

• D: 500 cm2

6. A coffee bean is about 0.5 cm3

in volume. How many

could fit in a 2 liter bottle?

• A: 4 × 101

• B: 4 × 102

• C: 4 × 103

• D: 4 × 104

7. Let $\vec{v}$ = vx

ˆi + vy

ˆj represent a velocity vector. The wind velocity is 10 km/hr, Southwest. North and East vector components are positive, while South and West are negative. What are vx and vy?

• A: 7.1 and 7.1 km/hr

• B: -7.1 and 7.1 km/hr

• C: 7.1 and -7.1 km/hr

• D: -7.1 and -7.1 km/hr

8. What is the angle the velocity makes with the x-axis,

in the previous exercise?

• A: 225 degrees

• B: 180 degrees

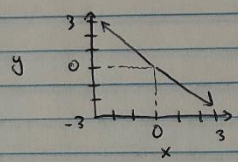
• C: 135 degrees

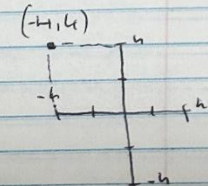
• D: 90 degrees

Pictures of problem sets below

9. a and b

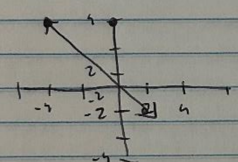
Sum of the vectors $\vec{v}$ : $\vec{v} + \vec{w} = (0,0)$




c. $\vec{v} - \vec{w} = -4\hat{i} + 4\hat{j} = (-4, 4)$

d.




e. $\vec{v} \cdot \vec{w} = (-2)(2) + (2)(-2) = -4 - 4 = -8$

<u>Unit 1</u>

1. a) $v = 15\ m/s + (3\ m/s) \cdot (4\ s)$
$= 15\ m/s + 12\ m/s = 27\ m/s$

b) $d = (15\ m/s) \cdot (4\ s) + \frac{1}{2}(3\ m/s) \cdot (4\ s)^2$
$= 60\ m + \frac{1}{2} \cdot 3\ m/s^2 \cdot 16\ s$
$= 60 + 24\ m = 84\ m$

c) $v_{avg} = \frac{15\ m/s + 27\ m/s}{2} = \frac{42}{2} = 21\ m/s$

There is a different avg then instantaneous

2. $v_p = \dfrac{988 - 338}{15 - 5} = 65\ m/s^{-1}$

$vq = \dfrac{2900 - 1500}{30 - 20} = 140\ m/s^{-1}$

b) Acceleration = positive

$\dfrac{140 - 65}{25 - 10\ s}\ m/s^{-1} = \dfrac{75}{15} = 5\ m/s^{-2}$

3. a. $d = \frac{(6\ m/s)^2 - (0\ m/s)^2}{2 \cdot 0.8\ m/s^2}$

$= \frac{36}{1.6} = 22.5\ m$

b. $t = \frac{6.0\ m/s - 0\ m/s}{0.8\ m/s^2}$

$= \frac{6}{0.8} = 7.5\ s$

4.

4. $R = \frac{v_0^2 \sin(2\theta)}{g}$

R is the range (60 m)

$v(0)$ is initial velocity

$\theta$ is launch angle

g is acceleration due to gravity (9.8 $m/s^2$)

$\sin(2\theta)$ is trigonometric factor

45°

$\sin(90)^\circ = 1$ $\quad R = \frac{v_0^2}{g}$

initial velocity $v_0 = \sqrt{60 \times 9.8}$

$= \sqrt{588}$

$= 24.25$ m/s

$T = \frac{2 v_0 \sin(\theta)}{g}$

$\sin(45^\circ) = \frac{1}{\sqrt{2}}$

$T = \frac{2 \times 24.25 \times \frac{1}{\sqrt{2}}}{9.8}$

time of flight $= \frac{34.30}{9.8} \approx 3.5$ s

5.

| Pendulum length | Period (T) | g (m/s) |
|---|---|---|
| avg 1.46 | 0.55 | 9.36 |

$\frac{L}{\left(\frac{T}{2\pi}\right)^2} = g \quad \frac{L}{\frac{T^2}{2^2\pi^2}}$

$T = 2\pi \sqrt{Lg} \quad \left(\frac{T}{2\pi}\right)^2 = \sqrt{Lg}$

$g\left(\frac{T}{2\pi}\right)^2 = Lg \quad \frac{L}{\left(\frac{T}{2\pi}\right)^2} = g$

$\frac{4\pi^2 L}{T^2} = g$

Error $\frac{9.365 - 9.81}{9.81} \times 100 \longrightarrow 4.54$ % error which is too low

Unit 2

1. a. $T = \frac{1000}{\sin(7°)} = 8205.58\ N$

b. $N = mg = 900 \times 9.8 = 8820\ N$

$F_f = 0.05 \times 8820 = 441\ N$

$F_{net} = 8206 \times \cos(7°) = 8206 \times 0.99255 \approx 8146\ N$

$8146 - 441 = 7705\ N$

$a = \frac{7705}{900} \approx 8.56\ m/s$

2. $v_i = 120\ km/h \times \frac{1000\ m}{1\ km} \times \frac{1h}{3600\ s} = \frac{120\ 000}{3600} \approx 33.33\ m/s$

$a = \frac{0 - (33.33)^2}{2 \times 100} \approx -5.555\ m/s^2$

b) $20\ 000\ kg \times (-5.555\ m/s^2)$

$F = -111{,}100\ N$

3.

3. $F_1 = 10\,N \rightarrow \uparrow 45°$ $F_2 = 8\,N \rightarrow \downarrow$ $F_3 = 7.5\,N$

$F_{1x} = 10\cos(45°) = 7.07\,N$ $F_{2x} = 8\cos(30) = 6.93\,N$

$F_{1y} = 10\sin(45°) = 7.07\,N$ $F_{2y} = 8\sin(30) = -4\,N$ $F_3 = 7.5\,x$

$= -7.5$

$F_x = (7.07 + 6.93 - 7.5)$ $F_y = 7.07 - 4 - 0 = 3.07$

$= 6.5$

$F_{net} = \sqrt{6.5^2 + 3.07^2}$ $-7.14\,N$ $a = \frac{-7.14}{50}$

$= .1438\,m/s^2$

a) $F_{1y} = 80{,}000\cos(30) = 69282.03\,N$

$F_{1x} = 80{,}000\sin(30) = \underline{40{,}000\,N}$

↳ centripetal force

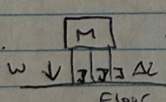
b) $600\,km/h$ $6000\,kg$

$r = \frac{mv^2}{F_c}$ $\frac{6000 \cdot (166.6^2)}{40\,000} \rightarrow \frac{4166.83\,m}{\text{turn radius}}$

$600\,km/h \rightarrow 166.6\,m/s$

c) $C = 2\pi r \rightarrow 2\pi(4166.83) = 13090.48$

$\frac{13090.48\,m}{166.6\,m/s^2} = 78{,}545$

4. a. 


$\downarrow mg \uparrow 3kx$

b. $F_{up} - F_{down} = 0$

$3kx - mg = 0$

$3kx = mg$

$x = \frac{mg}{3kx}$

c. $x = \frac{mg}{3kx}$ $\lim_{k \to \infty} x = \lim \frac{mg}{3kx} = 0$

displacement approach 0 which indicates that stiffer springs will stretch less or not stretch under weigth of mass

5. a) $V_t = \sqrt{\dfrac{2mg}{\rho C A}}$

$V_t = \sqrt{\dfrac{2 \times 60\ kg \times 9.81\ m/s^2}{1.2\ kg/m^3 \times 0.5 \times 0.25\ m^2}}$

$\approx 88.6\ m/s$

b) $A' = 100 \times A = 100 \times 0.25\ m^2 = 25\ m^2$

$V_t' = \sqrt{\dfrac{2 \times 60\ kg \times 9.81\ m/s^2}{1.2\ kg/m^3 \times 0.5 \times 25\ m^2}}$

$\approx 8.85\ m/s$

6. a. $\Delta L = \dfrac{F L_0}{A E}$

Force $= 10\,000\ N$

$L_0 = 10\ m$

Diameter column $= 0.2\ m$

$R = \dfrac{0.2}{2} = 0.1\ m$

Young Modulus $(E) = 45 \times 10^9\ N/m^2$

$A = \pi r^2 = \pi (0.1m)^2 = \pi (0.01) \approx 0.0314\ m^2$

$\Delta L = \dfrac{10\,000\ N \times 10\ m}{0.0314\ m^2 \times 45 \times 10^9\ N/m^2}$

$\Delta L \approx 7.06 \times 10^{-5}\ m$

$\approx 0.0706\ mm$

b. $E' = \dfrac{E}{2} = \dfrac{45 \times 10^9\ N/m^2}{2} = 22.5 \times 10^9\ N/m^2$

$\Delta L' = \dfrac{F L_0}{A E'}$ $\quad \Delta L' = \dfrac{10{,}000\ N \times 10\ m}{0.0314\ m^2 \times 22.5 \times 10^9\ N/m^2}$

$\approx 1.414 \times 10^{-4}\ m$

$\approx 0.1414\ mm$

Unit 3

net force acting down the incline

1. a $F_{net} = F_{gravity,\ parallel} - F_{friction} = mg\sin\theta - \mu(mg\cos\theta)$

Newton's 2nd Law $F_{net} = ma$

$ma = mg\sin\theta - \mu(mg\cos\theta)$

$m \neq 0$ $a = g\sin\theta - \mu g\cos\theta$

Factoring g $a = g(\sin\theta - \mu\cos\theta)$

b. $a = g(\sin\theta - 0\cdot\cos\theta) = g\sin\theta$

$a = g\sin\theta$

2. incline angle $(\theta) = 10^\circ$

Acceleration due to gravity (g) $9.81\ m/s^2$

coef of kinetic friction $\approx 0.1$

$a = g(\sin\theta - \mu\cos\theta)$

$\sin(10^\circ) = 0.1736$

$\cos(10^\circ) = 0.9848$

$a = 9.81\ m/s^2(\sin(10^\circ) - 0.1\cos(10^\circ))$

$= 9.81\ m/s^2(0.1736 - 0.1 \times 0.9848)$

$= 9.81\ m/s^2(0.07512)$

$a \approx 0.736\ m/s^2$

b) $d = v_0 t + \frac{1}{2}at^2$

$d = 0\cdot 30 + \frac{1}{2}\cdot 0.736\cdot(30)^2$

$d = \frac{1}{2}\cdot 0.736\cdot 900$

$d \approx 331.2\ m$

$v = v_0 + at$

$v = 0 + 0.736\cdot 30$

$\approx 22.08\ m/s$