Physics 30
Physics 20 Review

Kinematics

1)

$\Delta d = 1.0$ m
$v = 1.3 \times 10^5$ m/s
$\Delta t = ?$

$$\Delta t = \frac{\Delta d}{v}$$
$$\Delta t = \frac{1.0\,m}{1.3\times10^{5}\,m/s}$$
$$\Delta t = 7.7\times10^{-6}\,s$$

---

2)

$$v_{avg} = \frac{total\,distance}{total\,time}$$
$$v_{avg} = \frac{10km + 18km + 9.8km}{7.50\,min + 14.40\,min + 5.80\,min}$$
$$v_{avg} = 1.4\,km/min$$

---

3)

$v_1 = 10$ m/s
$v_2 = 30$ m/s
$\Delta t = 10$ s
$a = ?$

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$
$$\vec{a} = \frac{30_{m/s} - 10_{m/s}}{10\,s}$$
$$\vec{a} = +2.0\,m/s^2$$

---

4)

$v_1 = 40$ m/s
$v_2 = 0$
$\Delta t = 4.0$ s
$a = ?$

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$
$$\vec{a} = \frac{0 - 40_{m/s}}{1.0\,s}$$
$$\vec{a} = -10\,m/s^2$$

---

5)

$v_1 = 6.0$ m/s
$a = -2.0$ m/s^2
$v_2 = ?$

a)

$$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$$
$$\vec{v}_2 = 6.0\,\text{m/s} + (-2.0\,\tfrac{m}{s^2})(2.0s)$$
$$\vec{v}_2 = +2.0\,\text{m/s}$$

b)

$$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$$
$$\vec{v}_2 = 6.0\,\text{m/s} + (-2.0\,\tfrac{m}{s^2})(3.0s)$$
$$\vec{v}_2 = 0\,\text{m/s}$$

c)

$$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$$
$$\vec{v}_2 = 6.0\,\text{m/s} + (-2.0\,\tfrac{m}{s^2})(4.0s)$$
$$\vec{v}_2 = -2.0\,\text{m/s}$$

---

6)

$v_1 = 0$ m/s
$v_2 = 2.0 \times 10^7$ m/s
$\Delta d = 0.10$ m
$\Delta t = ?$
$a = ?$

$$\vec{a} = \frac{\vec{v}_2^2 - \vec{v}_1^2}{2\Delta\vec{d}}$$
$$\vec{a} = \frac{(2.0\times10^7\,\text{m/s})^2 - 0}{2(0.10\text{m})}$$
$$\vec{a} = 2.0\times10^{15}\,\tfrac{m}{s^2}$$

$$\Delta t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}}$$
$$\Delta t = \frac{2.0\times10^7\,\text{m/s} - 0}{2.0\times10^{15}\,\tfrac{m}{s^2}}$$
$$\Delta t = 1.0\times10^{-8}\,\text{s}$$

7)

$v_1 = 500$ m/s
$v_2 = 0$
$a = –9.81$ m/s^2
Δd = ?
Δt = ?

a)

$$\Delta t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}}$$

$$\Delta t = \frac{0 - 500\text{m/s}}{-9.81\,\text{m/s}^2}$$

$$\Delta t = 51\text{s}$$

b)

$$\Delta \vec{d} = \frac{\vec{v}_1 + \vec{v}_2}{2}\Delta t$$

$$\Delta \vec{d} = \frac{500\text{m/s} + 0}{2}(51\text{s})$$

$$\Delta \vec{d} = 1.3 \times 10^4\,\text{m}$$

---

8)

$v_1 = +9.0$ m/s
$\Delta d = –80$ m
$a = –9.81$ m/s^2
v_2 = ?
Δt = ?

calculate the velocity just before it hits the ground

$$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta\vec{d}$$

$$\vec{v}_2 = -\sqrt{\vec{v}_1^2 + 2\vec{a}\Delta\vec{d}}$$

$$\vec{v}_2 = -\sqrt{(9.0\text{m/s})^2 + 2(-9.81\,\text{m/s}^2)(-80\text{m})}$$

$$\vec{v}_2 = -40.6\,\text{m/s}$$

Now we can calculate the total time

$$\Delta t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}}$$

$$\Delta t = \frac{-40.6\text{m/s} - 9.0\text{m/s}}{-9.81\,\text{m/s}^2}$$

$$\Delta t = 5.1\text{s}$$

---

9)

v_1 = 0 m/s
Δd = –20 m
a = –9.81 m/s^2
v_2 = ?
Δt = ?

calculate the velocity just before it hits the ground

$$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta\vec{d}$$
$$\vec{v}_2 = -\sqrt{\vec{v}_1^2 + 2\vec{a}\Delta\vec{d}}$$
$$\vec{v}_2 = -\sqrt{0 + 2(-9.81 \, m/s^2)(-20m)}$$
$$\vec{v}_2 = -19.6 \, m/s$$

calculate the time

$$\Delta t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}}$$
$$\Delta t = \frac{-19.6 - 0}{-9.81 \, m/s^2}$$
$$\Delta t = 2.0 \, s$$

---

10)

v_1 = +11 m/s
a = –9.81 m/s^2
v_2 = 0
Δd = ?
Δt = ?

calculate the time up

$$\Delta t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}}$$
$$\Delta t = \frac{0 - 11 m/s}{-9.81 \, m/s^2}$$
$$\Delta t = 1.12 \, s$$

total time

Δt = 1.12 s x 2
Δt =2.2 s

$$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta\vec{d}$$
$$\Delta\vec{d} = \frac{\vec{v}_2^2 - \vec{v}_1^2}{2\vec{a}}$$
$$\Delta\vec{d} = \frac{0 - 11 m/s}{2(-9.81 m/s^2)}$$
$$\Delta\vec{d} = 6.2 m$$

---

11)

v_1 = +19.62 m/s
Δd = –117.82 m
a = –9.81 m/s^2
v_2 = ?
Δt = ?

calculate the velocity just before it hits the ground

$$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta\vec{d}$$

$$\vec{v}_2 = -\sqrt{\vec{v}_1^2 + 2\vec{a}\Delta\vec{d}}$$

$$\vec{v}_2 = -\sqrt{(19.62\,\text{m/s})^2 + 2(-9.81\,\text{m/s}^2)(-117.82\,\text{m})}$$

$$\vec{v}_2 = -51.9\,\text{m/s}$$

calculate the total time

$$\Delta t = \frac{\vec{v}_2 - \vec{v}_1}{\vec{a}}$$

$$\Delta t = \frac{-51.9\,\text{m/s} - 19.62\,\text{m/s}}{-9.81\,\text{m/s}^2}$$

$$\Delta t = 7.29\,\text{s}$$

---

12)

vertical

v_1 = 0 m/s
Δd = –117.82 m
a = –9.81 m/s^2
Δt = ?

$$\Delta\vec{d} = \vec{v}_1\Delta t + \tfrac{1}{2}\vec{a}\Delta t^2$$

$$\Delta\vec{d} = 0 + \tfrac{1}{2}\vec{a}\Delta t^2$$

$$\Delta t = \sqrt{\frac{2(-117.82\,\text{m})}{-9.81\,\text{m/s}^2}}$$

$$\Delta t = 4.90\,\text{s}$$

horizontal

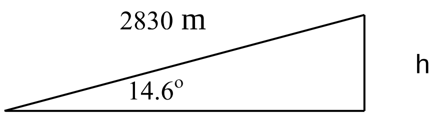
$$\Delta d = v\Delta t$$

$$\Delta d = 19.62\,\text{m/s}(4.90\,\text{s})$$

$$\Delta d = 96.2\,\text{m}$$

Vectors

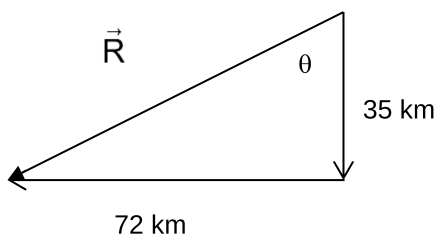
1)



$$\sin 14.6 = \frac{h}{2830}$$
$$h = 713\,\text{m}$$

---

2)



$$R = \sqrt{35.0^2 + 72.0^2}$$
$$R = 80.0\,\text{km/h}$$

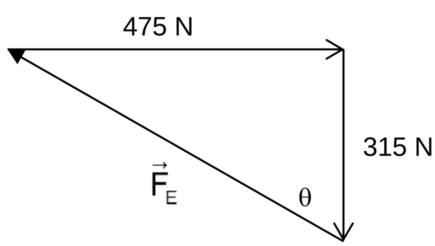
$$\theta = \tan^{-1}\left(\frac{72.0}{35.0}\right) = 64.1^{o}\ \text{W of S}$$

$$\vec{R} = 80.0\,\text{km/h} @ 64.1^{o}\ \text{W of S}$$

---

3)

Note that the vectors add up to zero.



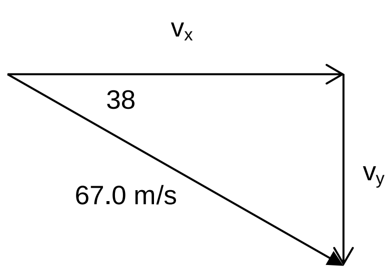
$$F_E = \sqrt{315^2 + 475^2}$$
$$F_E = 570\,\text{N}$$

$$\theta = \tan^{-1}\left(\frac{475}{315}\right) = 56^{o}\ \text{W of N}$$

$$\vec{F}_E = 570\,\text{N} @ 56^{o}\ \text{W of N}$$

---

4)

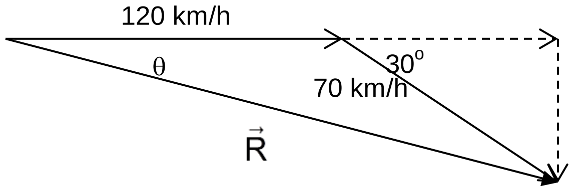


$$v_x = 67.0 \cos 38$$
$$v_x = 52.8\,\text{m/s east}$$

$$v_y = 67.0 \sin 38$$
$$v_y = 41.2\,\text{m/s south}$$

---

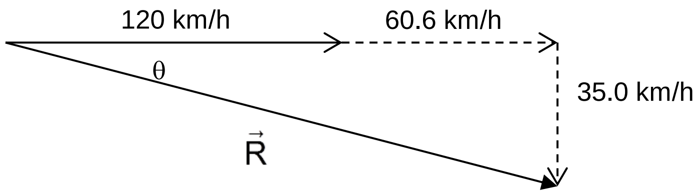
5)



Calculate the components of the wind vector and then add them to the airplane vector

$$v_{wx} = 70\cos 30$$
$$v_{wx} = 60.6\ {}^{km}\!/\!_{h}\ \text{east}$$

$$v_{wy} = 70\sin 30$$
$$v_{wy} = 35.0\ {}^{km}\!/\!_{h}\ \text{south}$$



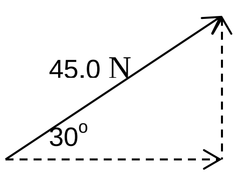
$$R = \sqrt{(120 + 60.6)^2 + 35.0^2}$$
$$R = 184\ \text{km/h}$$

$$\theta = \tan^{-1}\left(\frac{35.0}{102 + 60.6}\right) = 11^{o}\ \text{S of E}$$

$$\vec{R} = 184\ \text{km/h} @ 11^{o}\ \text{S of E}$$

---

6)

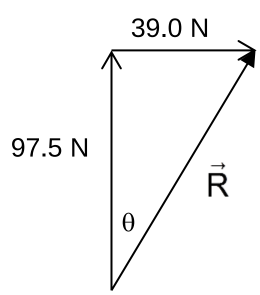


A_y = 45.0sin30
A_y = 22.5 N north

A_x = 45.0cos30
A_x = 39.0 N east

Calculate the components of each vector and then add them together.
R_x = 39.0 N east + 0
R_x =39.0 N east

R_y = 22.5 N north + 75 N north
R_y =97.5 N north

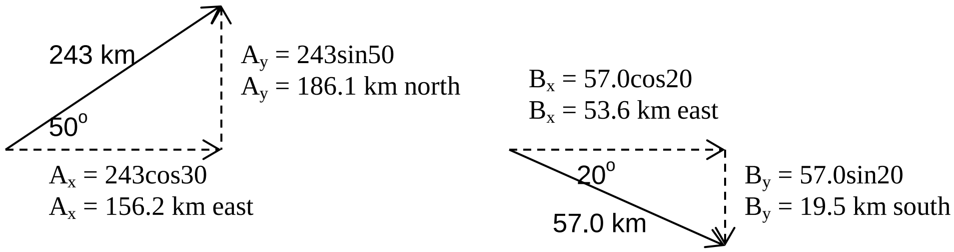


$$R = \sqrt{39.0^2 + 97.5^2}$$
$$R = 105\ \text{N}$$

$$\theta = \tan^{-1}\left(\frac{39.0}{97.5}\right) = 22^{o}\ \text{E of N}$$

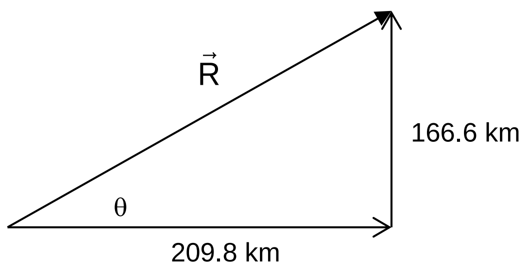
$$\vec{R} = 105\ \text{N} @ 22^{o}\ \text{E of N}$$

7)



Calculate the components of each vector and then add them together.
R_x = 156.2 km east + 53.6 km east
R_x =209.8 km east

R_y =186.1 km north + 19.5 km south
R_y =166.6 km north



$$R = \sqrt{209.8^2 + 166.6^2}$$
$$R = 268\,km$$

$$\theta = \tan^{-1}\left(\frac{166.6}{209.8}\right) = 38^o\ N\ of\ E$$

$$\vec{R} = 268\,km\ @\ 38^o\ N\ of\ E$$

Circular Motion

1)

$$v = \frac{\Delta d}{\Delta t} = \frac{2\pi r}{T} \qquad F_T = F_c = \frac{4\pi^2 mr}{T^2}$$

$$v = \frac{2\pi(2.8\,m)}{0.98\,s} \qquad F_T = \frac{4\pi^2(1.0\,kg)(2.8\,m)}{(0.98\,s)^2}$$

$$v = 18\,{}^{m}\!/\!_{s} \qquad F_T = 1.2\times10^2\,N$$

---

2)

$$F_f = F_c = \frac{mv^2}{r}$$

$$F_f = \frac{(822\,kg)(28.0\,{}^{m}\!/\!_{s})^2}{105\,m}$$

$$F_f = 6.14\times10^3\,N$$

---

3)

$$F_T = F_c = \frac{4\pi^2 mr}{T^2}$$

$$F_T = \frac{4\pi^2(1.7\,kg)(0.60\,m)}{(1.1s)^2}$$

$$F_T = 33\,N$$

Dynamics

1)

The car's tires exert a force on the pavement directed backwards. Newton's 3rd Law results in an opposite and equal reaction force of the pavement pushing the car forward. The car accelerating forward is a result of Newton's 2nd Law where an unbalanced force results in an acceleration. When the car reaches the speed limit, the forward force balances the frictional forces which, according to Newton's 1st Law, results in constant velocity.

---

2)

$$\vec{a} = \frac{\vec{F}}{m}$$

$$\vec{a} = \frac{(30.0\,N\,south)}{(10.0\,kg)}$$

$$\vec{a} = 3.00\,m/s^2\ south$$

---

3)

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$\vec{a} = \frac{-2.5\,m/s - 0}{8.7\,s}$$

$$\vec{a} = -0.287\,m/s^2$$

$$\vec{F} = m\vec{a}$$

$$\vec{F} = 22\,kg(-0.287\,m/s^2)$$

$$\vec{F} = -6.3\,N$$

---

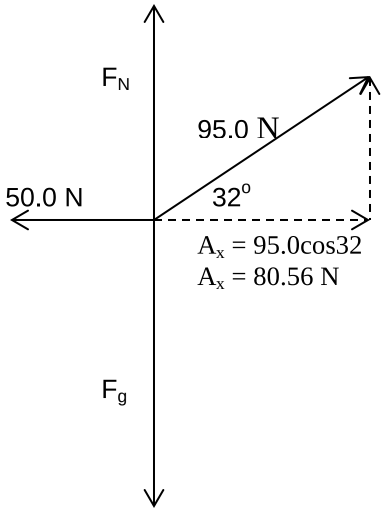
4)

$$\vec{a}_g = \frac{\vec{F}_g}{m}$$

$$\vec{a}_g = \frac{36.0\,N}{22.0\,kg}$$

$$\vec{a}_g = 1.64\,m/s^2$$

5)

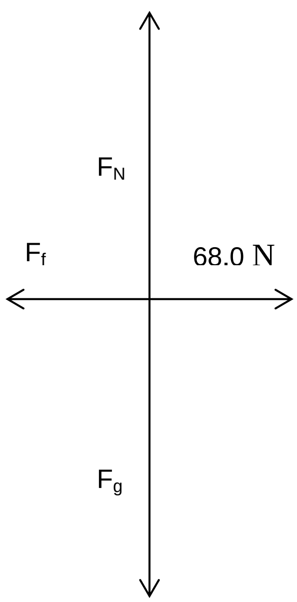


F_{net} = 80.56 N + (–50.0 N)
F_{net} = 30.56 N

$$\vec{a} = \frac{\vec{F}}{m}$$
$$\vec{a} = \frac{(30.56\,\text{N})}{(45.0\,\text{kg})}$$
$$\vec{a} = 0.679\,\text{m/s}^2$$

---

6)



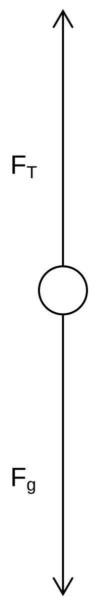
constant speed → a = 0
a = 0 → F_{net} = 0
∴ F_f = 68 N

$$\mu = \frac{F_f}{F_N}$$
$$\mu = \frac{68\,\text{N}}{245\,\text{N}}$$
$$\mu = 0.28$$

$$F_N = F_g$$
$$F_N = mg$$
$$F_N = 25\,\text{kg}(9.81\,\text{m/s}^2)$$
$$F_N = 245\,\text{N}$$

---

7)



$$\vec{F}_{net} = m\vec{a}$$
$$\vec{F}_T + \vec{F}_g = m\vec{a}$$
$$\vec{F}_T + m\vec{g} = m\vec{a}$$
$$\vec{F}_T = m\vec{a} - m\vec{g}$$
$$\vec{F}_T = m(\vec{a} - \vec{g})$$

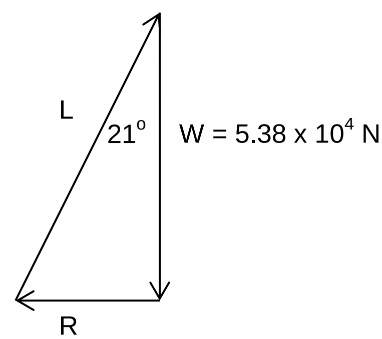
a)
$$\vec{F}_T = m(\vec{a} - \vec{g})$$
$$\vec{F}_T = 1200\,kg(-1.05\,{}^{m}\!/\!_{s^2} - (-9.81\,{}^{m}\!/\!_{s^2}))$$
$$\vec{F}_T = +1.05 \times 10^4\,N$$

b)
$$\vec{F}_T = m(\vec{a} - \vec{g})$$
$$\vec{F}_T = 1200\,kg(+1.05\,{}^{m}\!/\!_{s^2} - (-9.81\,{}^{m}\!/\!_{s^2}))$$
$$\vec{F}_T = +1.30 \times 10^4\,N$$

c) $\vec{a} = 0$
$$\vec{F}_T = m(\vec{a} - \vec{g})$$
$$\vec{F}_T = 1200\,kg(0 - (-9.81\,{}^{m}\!/\!_{s^2}))$$
$$\vec{F}_T = +1.18 \times 10^4\,N$$

---

8) constant speed $\rightarrow$ a = 0
a = 0 $\rightarrow$ F_{net} = 0
$\therefore$ The forces acting on the helicopter (lift, weight, air resistance) add up to zero.



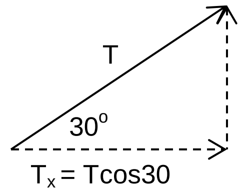
$$\cos 21 = \frac{W}{L}$$
$$L = \frac{W}{\cos 21} = \frac{5.38 \times 10^4 N}{\cos 21}$$
$$L = 5.76 \times 10^4 N$$

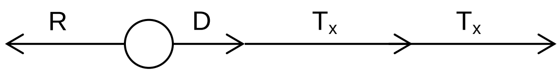
$$\tan 21 = \frac{R}{W}$$
$$R = W \tan 21 = 5.38 \times 10^4 N \tan 21$$
$$R = 2.07 \times 10^4 N$$

---

9)

In order for the tanker to go directly forward, $T_1 = T_2$





$$\vec{F}_{net} = m\vec{a}$$

$$2T_x + D - R = m\vec{a}$$

$$2T\cos 30 + D - R = m\vec{a}$$

$$T = \frac{m\vec{a} - D + R}{2\cos 30}$$

$$T = \frac{1.50\times10^{8}\,kg(0.00200\,m/s^2) - 7.50\times10^{4}\,N + 4.00\times10^{4}\,N}{2\cos 30}$$

$$T = 1.53\times10^{5}\,N$$