Physics 20 - Lesson 15
Forces & Dynamics – Problem Solving – Answer Key

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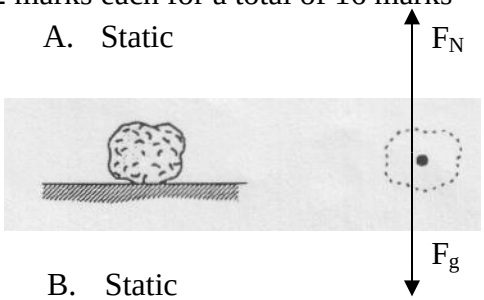
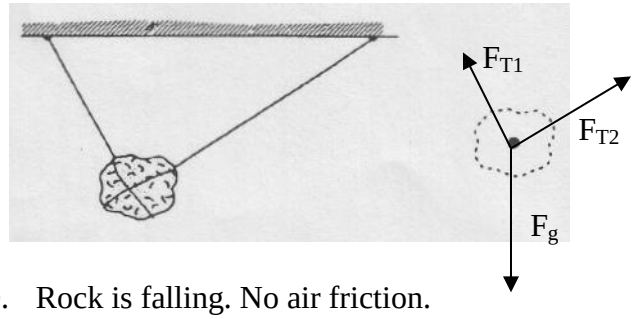
1) 2 marks each for a total of 16 marks

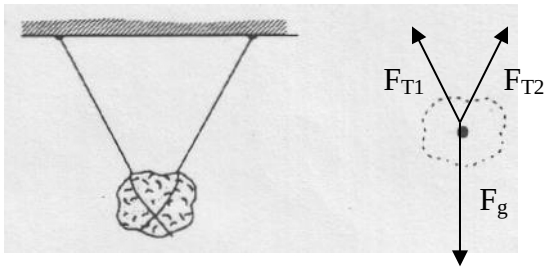
A. Static



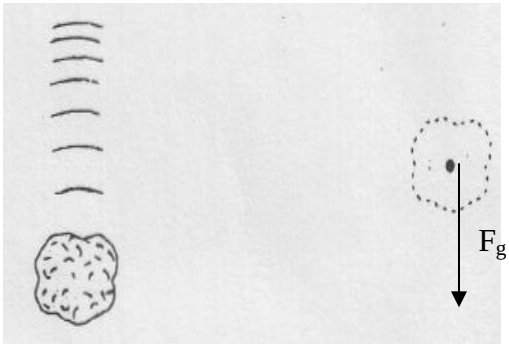
B. Static



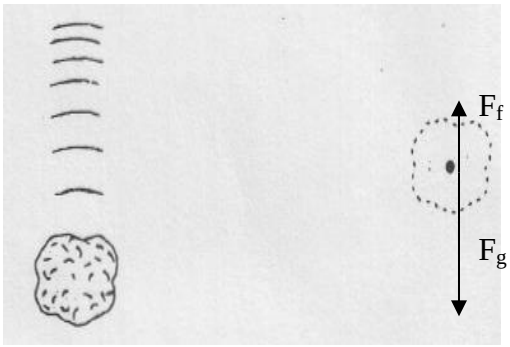
C. Static



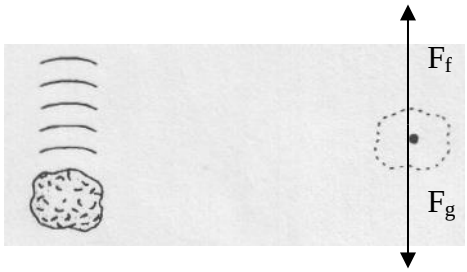
D. Rock is falling. No air friction.



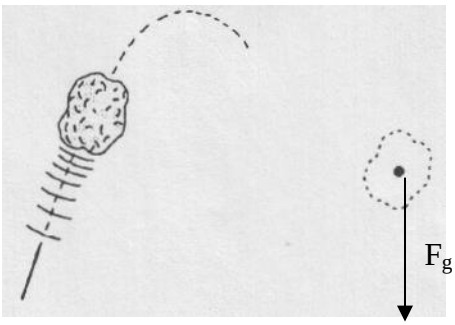
E. Rock is falling. Some air friction.



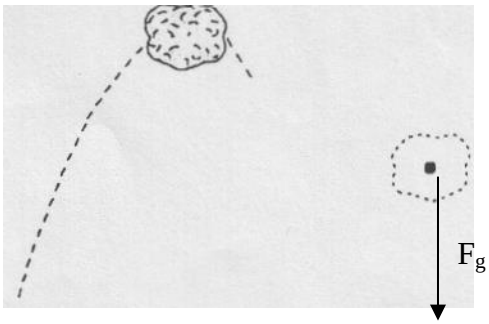
F. Falling at constant (terminal) velocity.



G. Rising in a parabolic trajectory.
No air resistance.



H. At the top of a parabolic trajectory.
No air resistance.



2) /3

$m = 300kg$
$F_{net} = ?$
$\vec{a} = 0.25\,{}^{m}/_{s^2}$

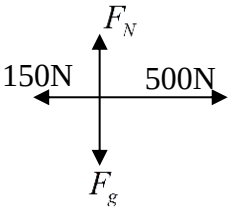
$\vec{F}_{net} = m\vec{a} = 300kg(0.25\,{}^{m}/_{s^2})$
$\boxed{\vec{F}_{net} = 75N}$

3) /5

$m = 0.400kg$
$F_{net} = 200N$
$\Delta t = 12.0s$
$V_1 = 0$
$V_2 = ?$

$a = \frac{F_{net}}{m} = \frac{220N}{0.400kg} = 500m/s^2$
$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t = 0 + 500m/s^2(12.0s)$
$\boxed{\vec{v}_2 = 6.00\times10^3 m/s}$

4) /7



$\vec{F}_{net} = 500N - 150N = 350N$
$\Delta t = 2.5s$
$v_1 = 20\,{}^{m}/_{s}$
$v_2 = 40\,{}^{m}/_{s}$
$\vec{a} = ?$

$a = \frac{v_2 - v_1}{t} = \frac{40\,{}^{m}/_{s} - 20\,{}^{m}/_{s}}{2.5s}$
$a = 8.0\,{}^{m}/_{s^2}$
$m = \frac{\vec{F}_{net}}{\vec{a}} = \frac{350N}{8.0\,{}^{m}/_{s^2}} = \boxed{44kg}$

5) /6

$m = 2.2kg$
$F_{net} = 2.50N$
$\Delta t = 8.0s$
$v_1 = ?$
$v_2 = 70\,{}^{m}/_{s}$
$\vec{a} = ?$

$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{2.50N}{2.2kg} = 1.14\,{}^{m}/_{s^2}$

$v_1 = v_2 - \vec{a}t$
$v_1 = 70\,{}^{m}/_{s} - (1.14\,{}^{m}/_{s^2})(8.0s)$
$\boxed{v_1 = +61\,{}^{m}/_{s}}$

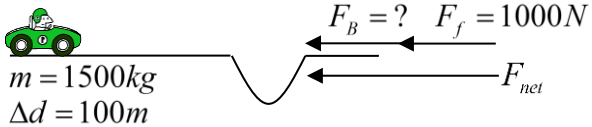
6) /6

$m = 4000kg$
$F_{net} = ?$
$\Delta t = 20s$
$v_1 = -26\,{}^{m}/_{s}$
$v_2 = -2.0\,{}^{m}/_{s}$
$\vec{a} = ?$

$a = \frac{v_2 - v_1}{t} = \frac{-2.0\,{}^{m}/_{s} - (-26\,{}^{m}/_{s})}{20s}$
$a = +1.2\,{}^{m}/_{s^2}$

$\vec{F}_{net} = m\vec{a}$
$\vec{F}_{net} = 4000kg(1.2m/s^2)$
$\boxed{\vec{F}_{net} = 4800N}$

7)



$m = 1500kg$
$\Delta d = 100m$
$v_1 = +20\,{}^{m}/_{s}$
$v_2 = 0$

/8

$$\vec{v}_2{}^2 = v_1{}^2 + a\Delta d$$
$$a = \frac{-v_1{}^2}{2\Delta d} = \frac{-(20\,{}^{m}/_{s})^2}{2(100m)}$$
$$a = -2.0\,{}^{m}/_{s^2}$$

$$\vec{F}_{net} = m\vec{a} = 1500kg(-2.0\,{}^{m}/_{s^2})$$
$$\boxed{\vec{F}_{net} = -3000N}$$

8)

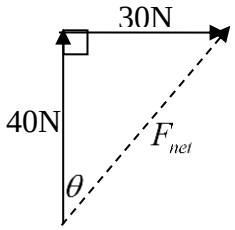
$m = 0.020kg$
$F = ?$
$a = ?$
$v_1 = 320\,{}^{m}/_{s}$
$v_2 = 0$
$\Delta d = 0.060m$

/6

$$\vec{v}_2{}^2 = v_1{}^2 + 2a\Delta d$$
$$a = \frac{\vec{v}_2{}^2 - v_1{}^2}{2\Delta d} = \frac{0-(320\,{}^{m}/_{s})^2}{2(0.060m)}$$
$$a = -8.5\times10^5\,{}^{m}/_{s^2}$$

$$F = ma = 0.020kg(-8.5\times10^5\,{}^{m}/_{s^2})$$
$$\boxed{F = -1.7\times10^4\,N}$$

9)



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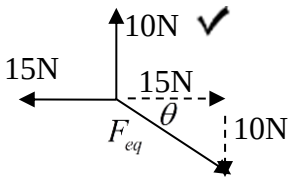
$$F_{net} = \sqrt{30^2 + 40^2} = 50N$$

$$\theta = \tan^{-1}\frac{30}{40} = 36.9°\text{ E of N}$$

$$\boxed{F_{net} = 50N\ [36.9°\text{ E of N}]}$$

10)



/5

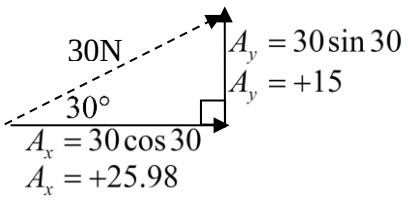
$$F_{eq} = \sqrt{10^2 + 15^2} = 18.0N$$

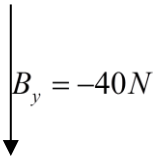
$$\theta = \tan^{-1}\frac{10}{15} = 33.7°\text{ S of E}$$

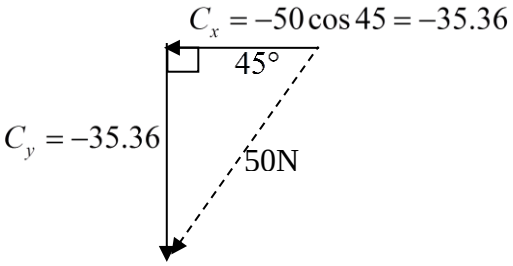
$$\boxed{F_{eq} = 18.0N\ [33.7°\text{ S of E}]}$$

11)

/10

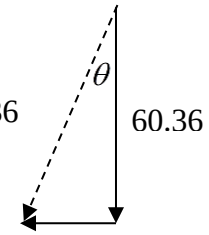






$F_{net\ x} = 25.98 - 35.36 = -9.38$

$F_{net\ y} = 15 - 40 - 35.36 = -60.36$



$F_{net} = \sqrt{60.36^2 + 9.38^2} = 61.1N$

$\theta = \tan^{-1}\dfrac{9.38}{60.36} = 8.8°$ W of S

$\vec{a} = \dfrac{\vec{F}_{net}}{m} = \dfrac{61.1N\ [8.8°\text{ W of S}]}{20}$

$\boxed{\vec{a} = 3.05\,{}^{m}\!/_{s^2}\ [8.8°\text{ W of S}]}$

12)

/8

$m = 0.0080kg$
$v_1 = 400\,{}^{m}\!/_{s}$
$v_2 = 100\,{}^{m}\!/_{s}$
$\Delta t = 4.0\times10^{-4}s$
$\vec{a} = ?$
$\vec{F} = ?$
$\Delta\vec{d} = ?$

a)

$\vec{a} = \dfrac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \dfrac{100m/s - 400m/s}{4.0\times10^{-4}s} = -7.5\times10^5 m/s^2$

$\vec{F} = m\vec{a} = 0.0080kg(-7.5\times10^5 m/s^2) = \boxed{-6000N}$

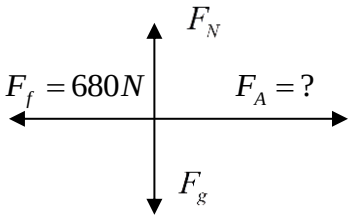
b)

$\Delta d = \left(\dfrac{\vec{v}_2 - \vec{v}_1}{2}\right)\Delta t = \left(\dfrac{100\,{}^{m}\!/_{s} - 400\,{}^{m}\!/_{s}}{2}\right)\left(4.0\times10^{-4}s\right)$

$\boxed{\Delta d = 0.10m}$

13) a)

/6



$v_1 = 0$
$v_2 = 72\,{}^{km}/_{h} \div 3.6 = 20\,{}^{m}/_{s}$
$\Delta t = 25s$
$a = ?$

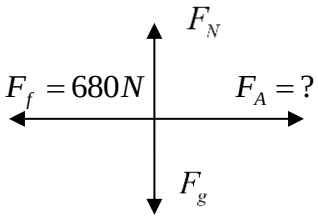
$\vec{a} = \dfrac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \dfrac{20\,{}^{m}/_{s} - 0}{25s}$
$\vec{a} = +0.80\,{}^{m}/_{s^2}$

$\vec{F}_{net} = m\vec{a} = 1600kg(+0.80\,{}^{m}/_{s^2})$
$\vec{F}_{net} = 1280N$

$\vec{F}_{net} = \vec{F}_A + \vec{F}_f$
$+1280N = \vec{F}_A + (-680N)$
$\boxed{\vec{F}_A = +1960N}$

b)

/6



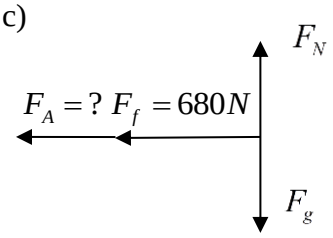
$a = 0$

$\vec{F}_{net} = m\vec{a} = 0$

$\vec{F}_{net} = \vec{F}_A + \vec{F}_f$
$0 = \vec{F}_A + (-680N)$
$\boxed{\vec{F}_A = +680N}$

c)

/6



$v_1 = 72\,{}^{km}/_{h} \div 3.6 = 20\,{}^{m}/_{s}$
$v_2 = 0$
$\Delta t = 32s$
$a = ?$

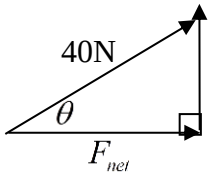
$\vec{a} = \dfrac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \dfrac{0 - 20\,{}^{m}/_{s}}{32s}$
$\vec{a} = -0.625\,{}^{m}/_{s^2}$

$\vec{F}_{net} = m\vec{a} = 1600kg(-0.625\,{}^{m}/_{s^2})$
$\vec{F}_{net} = -1000N$

$\vec{F}_{net} = \vec{F}_A + \vec{F}_f$
$-1000N = \vec{F}_A + (-680N)$
$\boxed{\vec{F}_A = -320N}$

14)

/4



$\vec{F}_{net} = m\vec{a} = 10kg(3.5\,{}^{m}/_{s^2})$
$\vec{F}_{net} = 35N$

$\theta = \cos^{-1}\dfrac{35}{40} = 29^\circ$

$\boxed{\theta = 29^\circ \text{ up from horizontal}}$

15) /10

Marble A

$m = 0.020kg$

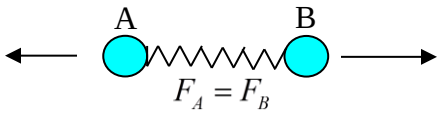
$v_1 = 0$

$v_2 = -15m/s$

$\Delta t = 0.0350s$

$a_A = ?$

$F_A = ?$



$$\vec{a}_A = \frac{v_2 - v_1}{\Delta t} = \frac{-15m/s - 0m/s}{0.0350s}$$

$$\vec{a}_A = -428.6m/s^2$$

$$F_A = ma_A = (0.020kg)(-48.6m/s^2)$$

$$F_A = -8.57N$$

Marble B

$F_B = -F_A = -(-8.57N)$

$F_B = +8.57N$

$m_B = ?$

$v_1 = 0m/s$

$v_2 = 22m/s$

$\Delta t = 0.0350s$

$a_B = ?$

$$a_B = \frac{v_2 - v_1}{\Delta t} = \frac{22m/s - 0m/s}{0.035s}$$

$$a_B = 628.6m/s^2$$

$$F_B = m_B a_B$$

$$m_B = \frac{F_B}{a_B} = \frac{8.57N}{628.6m/s^2} = 0.0136kg$$

$$\boxed{m_B = 13.6g}$$