# Solutions aux Exercices du Gymnase

Ce document contient les solutions des exercices proposés dans le document *Physique du gymnase : exercices*. Ces solutions sont classées par ordre d'apparition dans les livres desquels les exercices ont été tirés. La première section présente les solutions aux exercices du Giancoli, la deuxième celles des exercices du Hecht et la troisième celles des deux autres exercices.

NB : les solutions du Giancoli sont en anglais et proviennent d'un fichier plus complet que l'on peut télécharger sur internet. Les solutions du Hecht proviennent du livre de solutions que l'on trouve notamment à la bibliothèque de l'EPFL.

## Solutions aux exercices tirés du Giancoli

### Chapitre 2

41. The origin is the location of the car at the beginning of the reaction time. The initial speed of the car is $(95\,\text{km/h})\left(\frac{1\,\text{m/s}}{3.6\,\text{km/h}}\right) = 26.39\,\text{m/s}$. The location where the brakes are applied is found from the equation for motion at constant velocity: $x_0 = v_0 t_R = (26.39\,\text{m/s})(1.0\text{ s}) = 26.39\text{ m}$. This is now the starting location for the application of the brakes. In each case, the final speed is 0.

(*a*) Solve Eq. 2-12c for the final location.

$$v^2 = v_0^2 + 2a(x - x_0) \quad \rightarrow \quad x = x_0 + \frac{v^2 - v_0^2}{2a} = 26.39\text{ m} + \frac{0 - (26.39\,\text{m/s})^2}{2(-5.0\,\text{m/s}^2)} = \boxed{96\,\text{m}}$$

(*b*) Solve Eq. 2-12c for the final location with the second acceleration.

$$x = x_0 + \frac{v^2 - v_0^2}{2a} = 26.39\text{ m} + \frac{0 - (26.39\,\text{m/s})^2}{2(-7.0\,\text{m/s}^2)} = \boxed{76\,\text{m}}$$

48. Choose downward to be the positive direction, and take $y_0 = 0$ at the top of the cliff. The initial velocity is $v_0 = 0$, and the acceleration is $a = 9.80\,\text{m/s}^2$. The displacement is found from Eq. 2-12b, with $x$ replaced by $y$.

$$y = y_0 + v_0 t + \tfrac{1}{2}at^2 \quad \rightarrow \quad y - 0 = 0 + \tfrac{1}{2}(9.80\,\text{m/s}^2)(3.75\text{ s})^2 \quad \rightarrow \quad y = \boxed{68.9\text{ m}}$$

$$y = y_0 + v_{y0}t + \tfrac{1}{2}a_y t^2 \quad \rightarrow \quad y = 0 + 0 + \tfrac{1}{2}(9.80\,\text{m/s}^2)(3.0\,\text{s})^2 = \boxed{44\,\text{m}}$$

The distance from the base of the cliff to where the diver hits the water is found from the horizontal motion at constant velocity:

$$\Delta x = v_x t = (2.3\,\text{m/s})(3.0\,\text{s}) = \boxed{6.9\,\text{m}}$$

### Chapitre 4

$\boxed{1.}$ Use Newton's second law to calculate the force.

$$\sum F = ma = (55\text{ kg})(1.4\,\text{m/s}^2) = \boxed{77\,\text{N}}$$

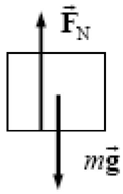
2. Use Newton's second law to calculate the mass.

$$\sum F = ma \quad \rightarrow \quad m = \frac{\sum F}{a} = \frac{265\text{ N}}{2.30\,\text{m/s}^2} = \boxed{115\text{ kg}}$$

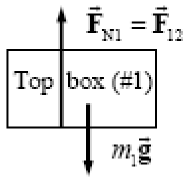
4. Use Newton's second law to calculate the tension.

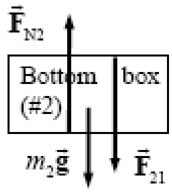
$$\sum F = F_T = ma = (1210\,\text{kg})(1.20\,\text{m/s}^2) = 1452\,\text{N} \approx \boxed{1.45\times10^3\,\text{N}}$$

10. (*a*) The 20.0 kg box resting on the table has the free-body diagram shown. Its weight is $mg = (20.0\text{ kg})(9.80\,\text{m/s}^2) = \boxed{196\,\text{N}}$. Since the box is at rest, the net force on the box must be 0, and so the normal force must also be $\boxed{196\,\text{N}}$.




(*b*) Free-body diagrams are shown for both boxes. $\vec{F}_{12}$ is the force on box 1 (the top box) due to box 2 (the bottom box), and is the normal force on box 1. $\vec{F}_{21}$ is the force on box 2 due to box 1, and has the same magnitude as $\vec{F}_{12}$ by Newton's third law. $\vec{F}_{N2}$ is the force of the table on box 2. That is the normal force on box 2. Since both boxes are at rest, the net force on each box must be 0. Write Newton's second law in the vertical direction for each box, taking the upward direction to be positive.



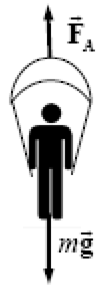

$$\sum F_1 = F_{N1} - m_1 g = 0$$

$$F_{N1} = m_1 g = (10.0\,\text{kg})(9.80\,\text{m/s}^2) = \boxed{98.0\text{ N}} = F_{12} = F_{21}$$

$$\sum F_2 = F_{N2} - F_{21} - m_2 g = 0$$

$$F_{N2} = F_{21} + m_2 g = 98.0\text{ N} + (20.0\,\text{kg})(9.80\,\text{m/s}^2) = \boxed{294\text{ N}}$$

22. (*a*) There will be two forces on the skydivers – their combined weight, and the upward force of air resistance, $\vec{F}_A$. Choose up to be the positive direction. Write Newton's second law for the skydivers.




$$\sum F = F_A - mg = ma \rightarrow 0.25mg - mg = ma \rightarrow$$

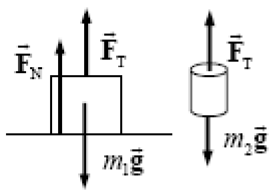
$$a = -0.75g = -0.75(9.80\,\text{m/s}^2) = \boxed{-7.35\,\text{m/s}^2}$$

Due to the sign of the result, the direction of the acceleration is down.

(*b*) If they are descending at constant speed, then the net force on them must be zero, and so the force of air resistance must be equal to their weight.

$$F_A = mg = (132\text{ kg})(9.80\,\text{m/s}^2) = \boxed{1.29\times10^3\,\text{N}}$$

27. Free-body diagrams for the box and the weight are shown below. The tension exerts the same magnitude of force on both objects.




(*a*) If the weight of the hanging weight is less than the weight of the box, the objects will not move, and the tension will be the same as the weight of the hanging weight. The acceleration of the box will also be zero, and so the sum of the forces on it will be zero. For the box,

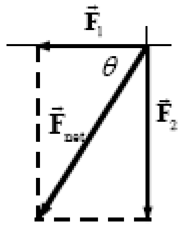
$$F_N + F_T - m_1 g = 0 \rightarrow F_N = m_1 g - F_T = m_1 g - m_2 g = 77.0\text{N} - 30.0\text{ N} = \boxed{47.0\text{ N}}$$

(*b*) The same analysis as for part (*a*) applies here.

$$F_N = m_1 g - m_2 g = 77.0\text{ N} - 60.0\text{ N} = \boxed{17.0\text{ N}}$$

(*c*) Since the hanging weight has more weight than the box on the table, the box on the table will be lifted up off the table, and normal force of the table on the box will be $\boxed{0\text{ N}}$.

$\boxed{37.}$ The net force in each case is found by vector addition with components.



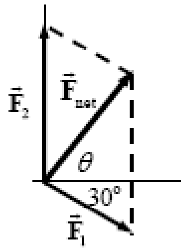

(*a*) $F_{Net\,x} = -F_1 = -10.2\text{ N} \quad F_{Net\,y} = -F_2 = -16.0\text{ N}$

$$F_{Net} = \sqrt{(-10.2)^2 + (-16.0)^2} = 19.0\text{ N} \qquad \theta = \tan^{-1}\frac{-16.0}{-10.2} = 57.48°$$

The actual angle from the $x$-axis is then $237.48°$. Thus the net force is

$$F_{Net} = \boxed{19.0\text{ N at }237.5°}$$

$$a = \frac{F_{Net}}{m} = \frac{19.0\text{ N}}{18.5\text{ kg}} = \boxed{1.03\text{ m/s}^2\text{ at }237.5°}$$



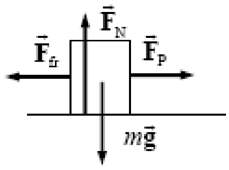

(*b*) $F_{Net\,x} = F_1\cos 30° = 8.833\text{ N} \quad F_{Net\,y} = F_2 - F_1\sin 30° = 10.9\text{ N}$

$$F_{Net} = \sqrt{(8.833\text{ N})^2 + (10.9\text{ N})^2} = 14.03\text{N} \approx \boxed{14.0\text{ N}}$$

$$\theta = \tan^{-1}\frac{10.9}{8.833} = \boxed{51.0°} \qquad a = \frac{F_{Net}}{m} = \frac{14.03\text{ N}}{18.5\text{ kg}} = \boxed{0.758\text{ m/s}^2}\text{ at }\boxed{51.0°}$$

## Chapitre 5

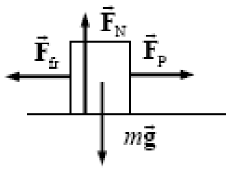
$\boxed{1.}$ A free-body diagram for the crate is shown. The crate does not accelerate vertically, and so $F_N = mg$. The crate does not accelerate horizontally, and so $F_P = F_{fr}$.




$$F_P = F_{fr} = \mu_k F_N = \mu_k mg = (0.30)(22\text{ kg})(9.80\text{ m/s}^2) = \boxed{65\text{ N}}$$

If the coefficient of kinetic friction is zero, then the horizontal force required is $\boxed{0\text{ N}}$, since there is no friction to counteract. Of course, it would take a force to START the crate moving, but once it was moving, no further horizontal force would be necessary to maintain the motion.

2. A free-body diagram for the box is shown. Since the box does not accelerate vertically, $F_N = mg$.




(*a*) To start the box moving, the pulling force must just overcome the force of static friction, and that means the force of static friction will reach its maximum value of $F_{fr} = \mu_s F_N$. Thus we have for the starting motion,

$$\sum F_x = F_P - F_{fr} = 0 \quad \rightarrow$$

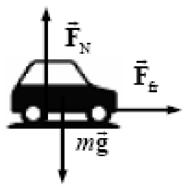
$$F_P = F_{fr} = \mu_s F_N = \mu_s mg \quad \rightarrow \quad \mu_s = \frac{F_P}{mg} = \frac{35.0\text{ N}}{(6.0\text{ kg})(9.80\text{ m/s}^2)} = \boxed{0.60}$$

(*b*) The same force diagram applies, but now the friction is kinetic friction, and the pulling force is NOT equal to the frictional force, since the box is accelerating to the right.

$$\sum F = F_P - F_{fr} = ma \quad \rightarrow \quad F_P - \mu_k F_N = ma \quad \rightarrow \quad F_P - \mu_k mg = ma \quad \rightarrow$$

$$\mu_k = \frac{F_P - ma}{mg} = \frac{35.0\text{ N} - (6.0\text{ kg})(0.60\text{ m/s}^2)}{(6.0\text{ kg})(9.80\text{ m/s}^2)} = \boxed{0.53}$$

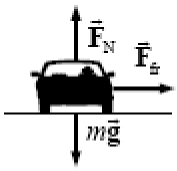
5. A free-body diagram for the accelerating car is shown. The car does not accelerate vertically, and so $F_N = mg$. The static frictional force is the accelerating force, and so $F_{fr} = ma$. If we assume the maximum acceleration, then we need the maximum force, and so the static frictional force would be its maximum value of $\mu_s F_N$. Thus we have




$$F_{fr} = ma \quad \rightarrow \quad \mu_s F_N = ma \quad \rightarrow \quad \mu_s mg = ma \quad \rightarrow$$

$$a = \mu_s g = 0.90(9.80\text{ m/s}^2) = \boxed{8.8\text{ m/s}^2}$$

34. A free-body diagram for the car at one instant of time is shown. In the diagram, the car is coming out of the paper at the reader, and the center of the circular path is to the right of the car, in the plane of the paper. If the car has its maximum speed, it would be on the verge of slipping, and the force of static friction would be at its maximum value. The vertical forces (gravity and normal force) are of the same magnitude, because the car is not accelerating vertically. We assume that the force of friction is the force causing the circular motion.




$$F_R = F_{fr} \rightarrow mv^2/r = \mu_s F_N = \mu_s mg \rightarrow$$

$$v = \sqrt{\mu_s rg} = \sqrt{(0.65)(80.0\,\text{m})(9.80\,\text{m/s}^2)} = 22.57\,\text{m/s} \approx \boxed{23\,\text{m/s}}$$

Notice that the result is $\boxed{\text{independent of the car's mass}}$.

35. (*a*) Find the centripetal acceleration from Eq. 5-1.

$$a_R = v^2/r = (1.30\,\text{m/s})^2/1.20\,\text{m} = 1.408\,\text{m/s}^2 \approx \boxed{1.41\,\text{m/s}^2}$$

(*b*) The net horizontal force is causing the centripetal motion, and so will be the centripetal force.

$$F_R = ma_R = (22.5\text{ kg})(1.408\,\text{m/s}^2) = 31.68\text{N} \approx \boxed{31.7\,\text{N}}$$

36. Find the centripetal acceleration from Eq. 5-1.

$$a_R = v^2/r = \frac{(525\,\text{m/s})^2}{4.80\times10^3\,\text{m}} = (57.42\,\text{m/s}^2)\left(\frac{1\,g}{9.80\,\text{m/s}^2}\right) = \boxed{5.86\,g\text{'s}}$$

38. The centripetal acceleration of a rotating object is given by $a_R = v^2/r$.

$$v = \sqrt{a_R r} = \sqrt{(1.25\times10^5 g)r} = \sqrt{(1.25\times10^5)(9.80\,\text{m/s}^2)(8.00\times10^{-2}\,\text{m})} = 3.13\times10^2\,\text{m/s}.$$

$$(3.13\times10^2\text{ m/s})\left(\frac{1\text{ rev}}{2\pi(8.00\times10^{-2}\text{m})}\right)\left(\frac{60\text{ s}}{1\text{ min}}\right) = \boxed{3.74\times10^4\,\text{rpm}}$$

$\boxed{43.}$ The orbit radius will be the sum of the Earth's radius plus the 400 km orbit height. The orbital period is about 90 minutes. Find the centripetal acceleration from these data.

$$r = 6380\,\text{km} + 400\,\text{km} = 6780\,\text{km} = 6.78\times10^6\,\text{m} \qquad T = 90\text{ min}\left(\frac{60\text{ sec}}{1\text{ min}}\right) = 5400\text{ sec}$$

$$a_R = \frac{4\pi^2 r}{T^2} = \frac{4\pi^2(6.78\times10^6\,\text{m})}{(5400\text{ sec})^2} = (9.18\,\text{m/s}^2)\left(\frac{1\,g}{9.80\,\text{m/s}^2}\right) = 0.937 \approx \boxed{0.9\,g\text{'s}}$$

$\boxed{49.}$ The radius of either skater's motion is 0.80 m, and the period is 2.5 sec. Thus their speed is given by $v = 2\pi r/T = \dfrac{2\pi(0.80\text{ m})}{2.5\text{ s}} = 2.0\,\text{m/s}$. Since each skater is moving in a circle, the net radial force on each one is given by Eq. 5-3.

$$F_R = mv^2/r = \frac{(60.0\text{ kg})(2.0\,\text{m/s})^2}{0.80\text{ m}} = \boxed{3.0\times10^2\,\text{N}}.$$

## Chapitre 6

$\boxed{1.}$ The spacecraft is at 3.00 Earth radii from the center of the Earth, or three times as far from the Earth's center as when at the surface of the Earth. Therefore, since the force of gravity decreases as the square of the distance, the force of gravity on the spacecraft will be one-ninth of its weight at the Earth's surface.

$$F_G = \tfrac{1}{9}mg_{\substack{\text{Earth's}\\\text{surface}}} = \frac{(1480\,\text{kg})(9.80\,\text{m/s}^2)}{9} = \boxed{1610\,\text{N}}$$

This could also have been found using Eq. 6-1, Newton's law of universal gravitation.

3. The acceleration due to gravity at any location on or above the surface of a planet is given by $g_{\text{planet}} = G M_{\text{planet}}/r^2$, where $r$ is the distance from the center of the planet to the location in question.

$$g_{\text{planet}} = G\frac{M_{\text{Planet}}}{r^2} = G\frac{M_{\text{Earth}}}{\left(2.3R_{\text{Earth}}\right)^2} = \frac{1}{2.3^2}G\frac{M_{\text{Earth}}}{R_{\text{Earth}}^2} = \frac{1}{2.3^2}g_{\text{Earth}} = \frac{9.80\,\text{m/s}^2}{2.3^2} = \boxed{1.9\,\text{m/s}^2}$$

8. We are to calculate the force on Earth, so we need the distance of each planet from Earth.

$$r_{\substack{\text{Earth}\\\text{Venus}}} = (150-108)\times10^6\text{ km} = 4.2\times10^{10}\,\text{m} \qquad r_{\substack{\text{Earth}\\\text{Jupiter}}} = (778-150)\times10^6\text{ km} = 6.28\times10^{11}\,\text{m}$$

$$r_{\substack{\text{Earth}\\\text{Saturn}}} = (1430-150)\times10^6\text{ km} = 1.28\times10^{12}\,\text{m}$$

Jupiter and Saturn will exert a rightward force, while Venus will exert a leftward force. Take the right direction as positive.

$$F_{\substack{\text{Earth-}\\\text{planets}}} = G\frac{M_{\text{Earth}}M_{\text{Jupiter}}}{r^2_{\substack{\text{Earth}\\\text{Jupiter}}}} + G\frac{M_{\text{Earth}}M_{\text{Saturn}}}{r^2_{\substack{\text{Earth}\\\text{Saturn}}}} - G\frac{M_{\text{Earth}}M_{\text{Venus}}}{r^2_{\substack{\text{Earth}\\\text{Venus}}}}$$

$$= GM^2_{\text{Earth}}\left(\frac{318}{\left(6.28\times10^{11}\text{m}\right)^2} + \frac{95.1}{\left(1.28\times10^{12}\text{m}\right)^2} - \frac{0.815}{\left(4.2\times10^{10}\text{m}\right)^2}\right)$$

$$= \left(6.67\times10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2\right)\left(5.97\times10^{24}\text{kg}\right)^2\left(4.02\times10^{-22}\,\text{m}^{-2}\right) = 9.56\times10^{17}\,\text{N} \approx \boxed{9.6\times10^{17}\,\text{N}}$$

The force of the Sun on the Earth is as follows.

$$F_{\substack{\text{Earth-}\\\text{Sun}}} = G\frac{M_{\text{Earth}}M_{\text{Sun}}}{r^2_{\substack{\text{Earth}\\\text{Sun}}}} = \left(6.67\times10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2\right)\frac{\left(5.97\times10^{24}\text{kg}\right)\left(1.99\times10^{30}\text{kg}\right)}{\left(1.50\times10^{11}\text{m}\right)^2} = 3.52\times10^{22}\,\text{N}$$

And so the ratio is $F_{\substack{\text{Earth-}\\\text{planets}}}/F_{\substack{\text{Earth-}\\\text{Sun}}} = 9.56\times10^{17}\text{N}/3.52\times10^{22}\text{N} = \boxed{2.7\times10^{-5}}$, which is 27 millionths.

$\boxed{37.}$ Use Kepler's third law for objects orbiting the Earth. The following are given.

$$T_2 = \text{period of Moon} = (27.4\text{ day})\left(\frac{86,400\text{ s}}{1\text{ day}}\right) = 2.367\times10^6\text{ sec}$$

$$r_2 = \text{radius of Moon's orbit} = 3.84\times10^8\,\text{m}$$

$$r_1 = \text{radius of near-Earth orbit} = R_{\text{Earth}} = 6.38\times10^6\,\text{m}$$

$$\left(T_1/T_2\right)^2 = \left(r_1/r_2\right)^3 \quad\rightarrow$$

$$T_1 = T_2\left(r_1/r_2\right)^{3/2} = \left(2.367\times10^6\text{sec}\right)\left(\frac{6.38\times10^6\,\text{m}}{3.84\times10^8\,\text{m}}\right)^{3/2} = \boxed{5.07\times10^3\text{sec}}\,(= 84.5\text{ min})$$

39. Use Kepler's third law for objects orbiting the Sun.

$$\left(T_{\text{Neptune}}/T_{\text{Earth}}\right)^2 = \left(r_{\text{Neptune}}/r_{\text{Earth}}\right)^3 \quad\rightarrow$$

$$T_{\text{Neptune}} = T_{\text{Earth}}\left(\frac{r_{\text{Neptune}}}{r_{\text{Earth}}}\right)^{3/2} = (1\text{ year})\left(\frac{4.5\times10^9\,\text{km}}{1.50\times10^8\,\text{km}}\right)^{3/2} = \boxed{160\text{ years}}$$

## Chapitre 7

$\boxed{1.}$ The force and the displacement are both downwards, so the angle between them is $0^\circ$. Use Eq. 7-1.

$$W_G = mgd\cos\theta = (280\,\text{kg})\left(9.80\,\text{m/s}^2\right)(2.80\,\text{m})\cos 0^\circ = \boxed{7.7\times10^3\,\text{J}}$$

5. The distance over which the force acts is the area to be mowed divided by the width of the mower. The force is parallel to the displacement, so the angle between them is $0^\circ$. Use Eq. 7-1.

$$W = Fd\cos\theta = F\frac{A}{w}\cos\theta = (15\,\mathrm{N})\frac{200\,\mathrm{m}^2}{0.50\,\mathrm{m}} = \boxed{6000\,\mathrm{J}}$$

41. Apply Eq. 7-1 to each segment of the motion.

$$W = W_1 + W_2 + W_3 = F_1 d_1\cos\theta_1 + F_2 d_2\cos\theta_2 + F_3 d_3\cos\theta_3$$
$$= (22\,\mathrm{N})(9.0\,\mathrm{m})\cos 0^\circ + (38\,\mathrm{N})(5.0\,\mathrm{m})\cos 12^\circ + (22\,\mathrm{N})(13.0\,\mathrm{m})\cos 0^\circ = \boxed{670\,\mathrm{J}}$$

50. Find the velocity from the kinetic energy, using Eq. 7-10.

$$K = \tfrac{1}{2}mv^2 \quad\rightarrow\quad v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2\left(6.21\times10^{-21}\,\mathrm{J}\right)}{5.31\times10^{-26}}} = \boxed{484\,\mathrm{m/s}}$$

51. (*a*) Since $K = \tfrac{1}{2}mv^2$, then $v = \sqrt{2K/m}$ and so $v \propto \sqrt{K}$. Thus if the kinetic energy is tripled, the speed will be multiplied by a factor of $\boxed{\sqrt{3}}$.

(*b*) Since $K = \tfrac{1}{2}mv^2$, then $K \propto v^2$. Thus if the speed is halved, the kinetic energy will be multiplied by a factor of $\boxed{1/4}$.

53. The work done on the car is equal to the change in its kinetic energy.

$$W = \Delta K = \tfrac{1}{2}mv_2^2 - \tfrac{1}{2}mv_1^2 = 0 - \tfrac{1}{2}(1300\,\mathrm{kg})\left[(95\,\mathrm{km/h})\left(\frac{1\,\mathrm{m/s}}{3.6\,\mathrm{km/h}}\right)\right]^2 = \boxed{-4.5\times10^5\,\mathrm{J}}$$

Note that the work is negative since the car is slowing down.

54. We assume the train is moving 20 m/s (which is about 45 miles per hour), and that the distance of "a few city blocks" is perhaps a half-mile, which is about 800 meters. First find the kinetic energy of the train, and then find out how much work the web must do to stop the train. Note that the web does negative work, since the force is in the OPPOSITE direction of the displacement.

$$W_{\substack{\text{to stop}\\ \text{train}}} = \Delta K = \tfrac{1}{2}mv_2^2 - \tfrac{1}{2}mv_1^2 = 0 - \tfrac{1}{2}\left(10^4\,\mathrm{kg}\right)(20\,\mathrm{m/s})^2 = -2\times10^6\,\mathrm{J}$$

$$W_{\text{web}} = -\tfrac{1}{2}kx^2 = -2\times10^6\,\mathrm{J} \quad\rightarrow\quad k = \frac{2\left(2\times10^6\,\mathrm{J}\right)}{\left(800\,\mathrm{m}^2\right)} = \boxed{6\,\mathrm{N/m}}$$

Note that this is not a very stiff "spring," but it does stretch a long distance.

56. The force exerted by the bow on the arrow is in the same direction as the displacement of the arrow. Thus $W = Fd\cos 0^\circ = Fd = (105\,\mathrm{N})(0.75\,\mathrm{m}) = 78.75\,\mathrm{J}$. But that work changes the kinetic energy of the arrow, by the work-energy theorem. Thus

$$Fd = W = K_2 - K_1 = \tfrac{1}{2}mv_2^2 - \tfrac{1}{2}mv_1^2 \quad\rightarrow\quad v_2 = \sqrt{\frac{2Fd}{m} + v_1^2} = \sqrt{\frac{2(78.75\,\mathrm{J})}{0.085\,\mathrm{kg}} + 0} = \boxed{43\,\mathrm{m/s}}$$

59. The net work done on the car must be its change in kinetic energy. By applying Newton's third law, the negative work done on the car by the spring must be the opposite of the work done in compressing the spring.

$$W = \Delta K = -W_{\text{spring}} \quad\rightarrow\quad \tfrac{1}{2}mv_2^2 - \tfrac{1}{2}mv_1^2 = -\tfrac{1}{2}kx^2 \quad\rightarrow$$

$$k = m\frac{v_1^2}{x^2} = (1200\,\mathrm{kg})\frac{\left[66\,\mathrm{km/k}\left(\dfrac{1\,\mathrm{m/s}}{3.6\,\mathrm{km/h}}\right)\right]^2}{(2.2\,\mathrm{m})^2} = \boxed{8.3\times10^4\,\mathrm{N/m}}$$

63. (*a*) The angle between the pushing force and the displacement is $32°$.

$$W_P = F_P d\cos\theta = (150\,\text{N})(5.0\,\text{m})\cos 32° = 636.0\,\text{J} \approx \boxed{640\,\text{J}}$$

(*b*) The angle between the force of gravity and the displacement is $122°$.

$$W_G = F_G d\cos\theta = mgd\cos\theta = (18\,\text{kg})(9.80\,\text{m/s}^2)(5.0\,\text{m})\cos 122° = -467.4\,\text{J} \approx \boxed{-470\,\text{J}}$$

(*c*) Because the normal force is perpendicular to the displacement, the work done by the normal force is $\boxed{0}$.

(*d*) The net work done is the change in kinetic energy.

$$W = W_P + W_g + W_N = \Delta K = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2 \rightarrow$$

$$v_f = \sqrt{\frac{2W}{m}} = \sqrt{\frac{2(636.0\,\text{J} - 467.4\,\text{J})}{(18\,\text{kg})}} = \boxed{4.3\,\text{m/s}}$$

82. (*a*) The pilot's initial speed when he hit the snow was 45 m/s. The work done on him as he fell the 1.1 m into the snow changed his kinetic energy. Both gravity and the snow did work on the pilot during that 1.1-meter motion. Gravity did positive work (the force was in the same direction as the displacement), and the snow did negative work (the force was in the opposite direction as the displacement).

$$W_{\text{gravity}} + W_{\text{snow}} = \Delta K \rightarrow mgd + W_{\text{snow}} = -\tfrac{1}{2}mv_i^2 \rightarrow$$

$$W_{\text{snow}} = -\tfrac{1}{2}mv_i^2 - mgd = -m\left(\tfrac{1}{2}v_i^2 + gd\right) = -(88\,\text{kg})\left[\tfrac{1}{2}(45\,\text{m/s})^2 + (9.80\,\text{m/s}^2)(1.1\,\text{m})\right]$$

$$= -9.005\times10^4\,\text{J} \approx \boxed{-9.0\times10^4\,\text{J}}$$

## Chapitre 8

2. Subtract the initial gravitational potential energy from the final gravitational potential energy.

$$\Delta U_{\text{grav}} = mgy_2 - mgy_1 = mg(y_2 - y_1) = (6.0\,\text{kg})(9.80\,\text{m/s}^2)(1.3\,\text{m}) = \boxed{76\,\text{J}}$$

5. (*a*) Relative to the ground, the potential energy is given by the following.

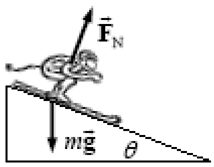
$$U_{\text{grav}} = mg\left(y_{\text{book}} - y_{\text{ground}}\right) = (1.95\,\text{kg})(9.80\,\text{m/s}^2)(2.20\,\text{m}) = \boxed{42.0\,\text{J}}$$

(*b*) Relative to the top of the person's head, the potential energy is given by the following.

$$U_{\text{grav}} = mg\left(y_{\text{book}} - y_{\text{head}}\right) = (1.95\,\text{kg})(9.80\,\text{m/s}^2)(2.20\,\text{m} - 1.60\,\text{m}) = 11.47\,\text{J} \approx \boxed{11\,\text{J}}$$

(*c*) The work done by the person in lifting the book from the ground to the final height is the same as the answer to part (*a*), $\boxed{42.0\,\text{J}}$. In part (*a*), the potential energy is calculated relative to the starting location of the application of the force on the book. The work done by the person is not related to the answer to part (*b*), because the potential energy is not calculated relative to the starting location of the application of the force on the book.

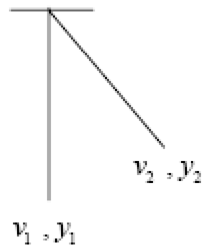
11. The forces on the skier are gravity and the normal force. The normal force is perpendicular to the direction of motion, and so does no work. Thus the skier's mechanical energy is conserved. Subscript 1 represents the skier at the top of the hill, and subscript 2 represents the skier at the bottom of the hill. The ground is the zero location for gravitational potential energy $(y = 0)$. We have $v_1 = 0$, $y_1 = 125\,\text{m}$, and $y_2 = 0$ (bottom of the hill). Solve for $v_2$, the speed at the bottom.




$$\tfrac{1}{2}mv_1^2 + mgy_1 = \tfrac{1}{2}mv_2^2 + mgy_2 \rightarrow 0 + mgy_1 = \tfrac{1}{2}mv_2^2 + 0 \rightarrow$$

$$v_2 = \sqrt{2gy_1} = \sqrt{2(9.80\,\text{m/s}^2)(125\,\text{m})} = \boxed{49\,\text{m/s}}\,(\approx 110\,\text{mi/h})$$

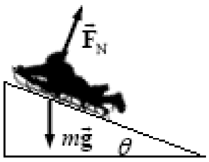
12. The only forces acting on Jane are gravity and the vine tension. The tension pulls in a centripetal direction, and so can do no work – the tension force is perpendicular at all times to her motion. So Jane's mechanical energy is conserved. Subscript 1 represents Jane at the point where she grabs the vine, and subscript 2 represents Jane at the highest point of her swing. The ground is the zero location for gravitational potential energy $(y = 0)$. We have $v_1 = 5.0\,\mathrm{m/s}$, $y_1 = 0$, and $v_2 = 0$ (top of swing). Solve for $y_2$, the height of her swing.




$$\tfrac{1}{2}mv_1^2 + mgy_1 = \tfrac{1}{2}mv_2^2 + mgy_2 \quad\to\quad \tfrac{1}{2}mv_1^2 + 0 = 0 + mgy_2 \quad\to$$

$$y_2 = \frac{v_1^2}{2g} = \frac{(5.0\,\mathrm{m/s})^2}{2(9.80\,\mathrm{m/s^2})} = 1.276\,\mathrm{m} \approx \boxed{1.3\,\mathrm{m}}$$

14. The forces on the sled are gravity and the normal force. The normal force is perpendicular to the direction of motion, and so does no work. Thus the sled's mechanical energy is conserved. Subscript 1 represents the sled at the bottom of the hill, and subscript 2 represents the sled at the top of the hill. The ground is the zero location for gravitational potential energy $(y = 0)$. We have $y_1 = 0$, $v_2 = 0$, and $y_2 = 1.12\,\mathrm{m}$. Solve for $v_1$, the speed at the bottom. Note that the angle is not used.




$$\tfrac{1}{2}mv_1^2 + mgy_1 = \tfrac{1}{2}mv_2^2 + mgy_2 \quad\to\quad \tfrac{1}{2}mv_1^2 + 0 = 0 + mgy_2 \quad\to$$

$$v_1 = \sqrt{2gy_2} = \sqrt{2(9.80\,\mathrm{m/s^2})(1.12\,\mathrm{m})} = \boxed{4.69\,\mathrm{m/s}}$$

45. (*a*) Equate the gravitational force to the expression for centripetal force, since the orbit is circular. Let $M_E$ represent the mass of the Earth.

$$\frac{m_s v_s^2}{r_s} = \frac{GM_E m_s}{r_s^2} \quad\to\quad m_s v_s^2 = \frac{GM_E m_s}{r_s} \quad\to\quad \tfrac{1}{2}m_s v_s^2 = \boxed{K = \frac{GM_E m_s}{2r_s}}$$

(*b*) The potential energy is given by Eq. 8-17, $\boxed{U = -GM_E m_s / r_s}$.

(*c*) $$\frac{K}{U} = \frac{\dfrac{GM_E m_s}{2r_s}}{-\dfrac{GM_E m_s}{r_s}} = \boxed{-\frac{1}{2}}$$

46. Since air friction is to be ignored, the mechanical energy will be conserved. Subscript 1 represents the rocket at launch, and subscript 2 represents the rocket at its highest altitude. We have $v_1 = 850\,\mathrm{m/s}$, $v_2 = 0$, and we take the final altitude to be a distance $h$ above the surface of the Earth.

$$E_1 = E_2 \quad\to\quad \tfrac{1}{2}mv_1^2 + \left(-\frac{GM_E m}{r_E}\right) = \tfrac{1}{2}mv_2^2 + \left(-\frac{GM_E m}{r_E + h}\right) \quad\to$$

$$h = \left(\frac{1}{r_E} - \frac{v_1^2}{2GM_E}\right)^{-1} - r_E = r_E\left(\frac{2GM_E}{r_E v_0^2} - 1\right)^{-1}$$

$$= (6.38\times10^6\,\mathrm{m})\left(\frac{2(6.67\times10^{-11}\,\mathrm{N\cdot m^2/kg^2})(5.98\times10^{24}\,\mathrm{kg})}{(6.38\times10^6\,\mathrm{m})(850\,\mathrm{m/s})^2} - 1\right)^{-1} = 3.708\times10^4\,\mathrm{m} \approx \boxed{3.7\times10^4\,\mathrm{m}}$$

If we would solve this problem with the approximate gravitation potential energy of $mgh$, we would get an answer of $3.686\times10^4\,\mathrm{m}$, which agrees to 2 significant figures.

62. The work necessary to lift the piano is the work done by an upward force, equal in magnitude to the weight of the piano. Thus $W = Fd\cos 0° = mgh$. The average power output required to lift the piano is the work done divided by the time to lift the piano.

$$P = \frac{W}{t} = \frac{mgh}{t} \quad \rightarrow \quad t = \frac{mgh}{P} = \frac{(335\text{ kg})(9.80\text{ m/s}^2)(16.0\text{ m})}{1750\text{ W}} = \boxed{30.0\text{ s}}$$

### Chapitre 10

5. (a) $\omega = \left(\frac{2500\text{ rev}}{1\text{ min}}\right)\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right) = 261.8\text{ rad/sec} \approx \boxed{260\text{ rad/sec}}$

(b) $v = \omega r = (261.8\text{ rad/sec})(0.175\text{ m}) = \boxed{46\text{ m/s}}$

$a_R = \omega^2 r = (261.8\text{ rad/sec})^2(0.175\text{ m}) = \boxed{1.2\times10^4\text{ m/s}^2}$

8. The angular speed of the merry-go-round is $2\pi\text{ rad}/4.0\text{ s} = 1.57\text{ rad/s}$.

(a) $v = \omega r = (1.57\text{ rad/sec})(1.2\text{ m}) = \boxed{1.9\text{ m/s}}$

(b) The acceleration is radial. There is no tangential acceleration.

$a_R = \omega^2 r = (1.57\text{ rad/sec})^2(1.2\text{ m}) = \boxed{3.0\text{ m/s}^2\text{ towards the center}}$

## Solutions aux exercices tirés du Hecht

### Chapitre 2

Exemple **2.12** : $v_{ct}$ = 5.00km/h – est, $v_{tT}$ = 10.00km/h – ouest et $v_{ic}$ = 0.01 km/h – ouest. À trouver : $v_{iT}$. La vitesse de l'insecte par rapport à la terre s'écrit comme suit : $\mathbf{v}_{iT} = \mathbf{v}_{ic} + \mathbf{v}_{ct} + \mathbf{v}_{tT}$ (on remarque que les couples de c et de t s'annulent) ces vecteurs étant parallèles, on peut les manipuler comme des valeurs algébriques, on décide de placer les valeurs positives vers l'est, ainsi $\mathbf{v}_{iT}$ = -0.01 km/h + 5.00 km/h + 10.00 km/h = 14.99 km/h – est.

Exemple **2.13** : $v_{JP} = v_{JT} + v_{TP}$. On n'a pas $v_{TP}$ mais $v_{TP} = -v_{PT}$. Nous avons donc $v_{JP} = v_{JT} - v_{PT}$ = (5.0 km/h – sud) – (25 km/h – nord) = 30 km/h – sud.

**2.18** L'équation de la vitesse en fonction du temps est donnée par la dérivée par rapport au temps de l'équation de la position : $v(t) = \frac{d}{dt}[4.0m + (8.2m/s)t] = 8.2m/s$

Position au temps t = 0s :

Y(0) = (8.2m/s)(0s) + 4.0m = 4.0m

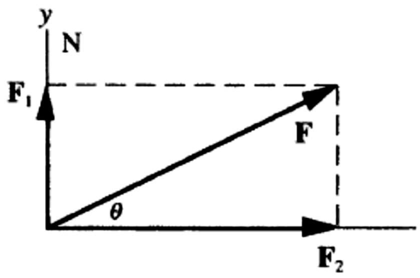
### Chapitre 5

**5.4**

Accélération du papa

Force résultante

$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{(120\text{ N})^2 + (50\text{ N})^2} = 130\text{ N}$$




Accélération

$$a = \frac{F}{m} = \frac{130\text{ N}}{100\text{ kg}} = 0{,}130\text{ m/s}^2$$

Orientation

$$\theta = \tan^{-1}\frac{(50\text{ N})}{(120\text{ N})} = 23°$$

$$\mathbf{a} = 0{,}13\text{ m/s}^2\text{ ; } 23°\text{ Nord de l'Est}$$

**5.17** Force de frottement due à la résistance de l'air

$\sum F = F_{sol} - F_g = - F_{tot}$

$F_{air} = F_g - F_{tot} = (65.0kg)(9.81m/s^2) - (65.0kg)(2.00m/s^2) = 508N$

**5.18** Force exercée par le sol

$\sum F = F_{sol} - F_g = m(4.0g)$ ; m étant la masse du parachutiste.

$F_{sol} = mg+m(4.0g)=5.0mg$

**5.42** Accélération centripète de l'enfant :

$a_c = \frac{v^2}{r} = \frac{(10.0m/s)^2}{200m} = 0.500m/s^2$

**5.45** Force centripète sur le joueur de baseball. Masse du joueur : $m = F_g/g$

Force centripète : $F_c = \frac{mv^2}{R} = \left(\frac{F_g}{g}\right)\frac{v^2}{R} = \frac{(845N)(6.1m/s)^2}{(9.81m/s^2)(4.88m)} = 6.6 \cdot 10^2 N$

C'est la force de frottement au sol qui produit la force centripète nécessaire à la course en rotation du joueur.

**5.63**

Coefficient de frottement

$$\mu = \frac{F_f}{F_N} = \frac{F_f}{mg} = \frac{(160\text{ N})}{(300\text{ N})} = 0{,}533$$

**5.65**

Accélération maximum

$$a = \frac{F_f}{m} = \frac{\mu_s F_N}{m} = \frac{\mu_s mg}{m} = \mu_s g$$

**5.68** Coefficient de frottement cinétique

La force de frottement égale la force motrice puisqu'il n'y a pas d'accélération : $\sum F = F_{tirer} - F_{fr}$

$\rightarrow F_{tirer} = F_{fr} = \mu_c F_N \rightarrow \mu_c = \frac{F_{tirer}}{F_N} = \frac{(60N)}{(30.0kg)(9.81m/s^2)} = 0.20$

**5.70** Force à exercer :

Coefficient de frottement : $\mu_s = \frac{F_{tirer}}{F_N} = \frac{(40N)}{(100N)} = 0.40$

Force à exercer : $F = F_{fr} = \mu_s F_N = (0.40)(150N) = 60N$

## Chapitre 7

**7.1**

Poids de l'objet

$$F = \frac{GmM_T}{r^2}$$

$$F' = \frac{G(2m)M_T}{(2r)^2}$$

$$\frac{F'}{F} = \frac{\frac{G(2m)M_T}{(2r)^2}}{\frac{GmM_T}{r^2}} = \frac{1}{2}$$

Le poids serait diminué de moitié.

**7.2** Sachant que $F = \frac{Gm_{bi}m_{bo}}{r^2}$, on trouve : $m_{bi} = \frac{Fr^2}{Gm_{bo}} = \frac{(1.48 \cdot 10^{-10}N)(0.30m^2)}{(6.67 \cdot 10^{-11}Nm^2/kg^2)(20kg)} = 0.010kg = 10g$

**7.4** Sachant que la force gravitationelle se définit par : $F = \frac{Gmm_T}{r^2}$, on trouve : $r = \sqrt{\frac{Gmm_T}{F}} = \sqrt{\frac{(6.67 \cdot 10^{-11}Nm^2/kg^2)(1.0kg)(5.975 \cdot 10^{24}kg)}{(1.0N)}} = 2.0 \cdot 10^7 m$

**7.7** Force gravitationelle entre Uranus et Neptune

$F = \frac{GM_U M_N}{r_{UN}^2} = \frac{(6.67 \cdot 10^{-11}Nm^2/kg^2)(14.6 \cdot 5.975 \cdot 10^{24}kg)(17.3 \cdot 5.975 \cdot 10^{24}kg)}{(4.9 \cdot 10^{12}m)^2} = 2.5 \cdot 10^{16} N$

## Chapitre 8

**8.12**

Vitesse angulaire (aiguille des secondes)

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{(2\pi \text{ rad})}{(60 \text{ s})} = 0{,}10 \text{ rad/s}$$

Vitesse angulaire (aiguille des minutes)

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{(2\pi \text{ rad})}{(3600 \text{ s})} = 1{,}745 \times 10^{-3} \text{ rad/s}$$

**8.26**

Vitesse angulaire des roues

$$\omega = \frac{v}{r} = \frac{(16 \text{ km/h})(10^3 \text{ m/km})(\text{h}/3600 \text{ s})}{\left(\frac{0{,}61 \text{ m}}{2}\right)} = 15 \text{ rad/s}$$

Temps pour 1 tour

$$t = \frac{\theta}{\omega} = \frac{(2\pi \text{ rad})}{(15 \text{ rad/s})} = 0{,}43 \text{ s}$$

**8.28**

Rayon de la poulie

Les pales et la poulie à laquelle elles sont reliées ont la même vitesse angulaire.

Vitesse angulaire des pales et de la poulie à laquelle elles sont reliées

$$\omega_p = \frac{v}{r} = \frac{(7{,}0\ \text{m/s})}{(1{,}0\ \text{m})} = 7{,}0\ \text{rad/s}$$

Puisque les 2 poulies sont reliées par une courroie, elles ont la même vitesse linéaire

$$v_m = v_p$$

$$\omega_m r_m = \omega_p r_p$$

Rayon de la poulie des pales

$$r_p = \frac{\omega_m r_m}{\omega_p} = \frac{(100\ \text{t/min})(2\pi\ \text{rad/t})(\text{min}/60\ \text{s})\left(\frac{0{,}20}{2}\ \text{m}\right)}{(7{,}0\ \text{rad/s})} = 0{,}15$$

**8.31**

Vitesse linéaire

$$v = r\omega = \left(\frac{0{,}51\ \text{m}}{2}\right)(100\ \text{t/min})(2\pi\ \text{rad/t})(\text{min}/60\ \text{s}) = 2{,}7\ \text{m/s}$$

**9.1**

Travail

$$W = Fd\cos\theta = (15\ \text{N})(1{,}5\ \text{m})(\cos 0°) = 23\ \text{J}$$

Le travail est effectué pour vaincre le frottement.

## Chapitre 9

**9.2**

Travail effectué par la force de 10 N (verticalement)

$$W = Fd\cos\theta = (10\ \text{N})(10\ \text{m})(\cos 0°) = 1{,}0\times10^2\ \text{J}$$

Le travail est effectué contre la gravité et pour donner de la vitesse à la masse.

Travail effectué par la force de 10 N (horizontalement)

$$W = Fd\cos\theta = (10\ \text{N})(10\ \text{m})(\cos 0°) = 1{,}0\times10^2\ \text{J}$$

Le travail est effectué uniquement pour donner de la vitesse à la masse. Dans ce cas, l'accélératic sera plus grande.

**9.3**

Travail du fromager

$$W = Fd\cos\theta = (20\ \text{N})(0{,}10\ \text{m})(\cos 0) = 2{,}0\ \text{J}$$

**9.4** Il faut choisir les bonnes informations : on cherche le travail du déménageur qui s'exprime par W=Fdcosθ. → $W_{dém}=F_{dém}d\cos\theta=(458.6N)(3.1m)\cos(14)=1.4\cdot10^3 J$

**9.6**

Travail contre le frottement

Force de frottement

$$F_f = \mu N = \mu mg = (0{,}02)(25\text{ kg})(9{,}81\text{ m/s}^2) = 4{,}9\text{ N}$$

Travail

$$W = Fd\cos\theta = (4{,}9\text{ N})(10\times10^3\text{ m})(\cos 0) = 4{,}9\times10^4\text{ J}$$

**9.7**

Force moyenne exercée

$$F = \frac{W}{d\cos\theta} = \frac{(400\text{ J})}{(100\text{ m})(\cos 0°)} = 4{,}00\text{ N}$$

**9.10**

Puissance de la grue

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{mgd}{t} = \frac{(100\text{ kg})(9{,}81\text{ m/s}^2)(30\text{ m})}{(30\text{ s})} = 9{,}8\cdot10^2\text{W}$$

**9.40**

Énergie cinétique d'une météorite

Noter que météorite est un mot féminin!

$$E_c = \frac{1}{2}mv^2 = \frac{1}{2}(1{,}0\times10^{-3}\text{ kg})(70\times10^3\text{ m/s})^2 = 2{,}5\times10^6\text{ J}$$

**9.41**

Énergie cinétique

$$E_c = \frac{1}{2}mv^2 = \frac{1}{2}(0{,}5\times10^{-3}\text{ kg})(200\times10^3\text{ m/s})^2 = 1\times10^7\text{ J}$$

Puissance

$$P = \frac{W}{t} = \frac{(1\times10^7\text{ J})}{(10\times10^{-9}\text{ s})} = 1\times10^{15}\text{ W}$$

**9.42**

Vitesse finale du vaisseau

$$v = \sqrt{\frac{2E_c}{m}} = \sqrt{\frac{2(7{,}4\times10^{16}\text{ J})}{(3{,}5\times10^6\text{ kg})}} = 2{,}1\times10^5\text{ m/s}$$

**9.71** Quelle voiture peut monter la colline ?

Hauteur possible pour chacune des voitures : $E_f = E_i$ → $mgh = mv^2/2$ ; $h = v^2/2g$

La hauteur pouvant être atteinte est indépendante de la masse. Les deux voitures vont s'arrêter à la même hauteur.

h = $\frac{[(96km/h)(1000m/km)(h/3600s)]^2}{2(9.81m/s^2)}$ =36m

Les deux voitures pourront atteindre le haut de la colline.

## Chapitre 10

**10.27** La force du ressort est : F=-kx. Ici, on connait F et x → $k=-F/x=(50N)/(0.05m)=1\cdot10^3$N/m

**10.28** L'énergie stockée dans un ressort est donnée par : $E_{res}=kx^2/2=(50N/m)(0.05)^2/2=0.02J$

## Solutions aux autres exercices

**Exercice 1 :**

A) Il s'agit d'un mouvement uniformément accéléré.
Pour trouver la vitesse, on utilise la formule $v(t) = v_0 + at$ ; on connait a par la donnée : $a = 1.5m/s^2$, il reste donc à trouver $v_0$.
On réorganise les termes de $v(t) = v_0 + at$ pour trouver $v_0 = v(t) - at$ ; puisque l'on connait par la donnée suivante : $v(2) = 82.8km/h$ on trouve $v_0 = v(2) - 2a$.
Attention à garder des unités cohérentes entre elles ! On choisit de tout exprimer en unités SI : $82.8km/h = 82.8 \cdot 1000m/3600s = 23m/s$. Donc $v_0 = v(2) - 2a = 23m/s – 2s\cdot 1.5m/s^2 = 20m/s$.
On peut alors exprimer v en fonction de t : $v(t) = v_0 + at = (20 + 1.5t)m/s$. La vitesse à t = 9s, est finalement calculée en remplaçant les termes : $v(9) = (20 + 1.5\cdot 9)m/s = 33.5m/s = 120.6km/h$.

B) On utilise la formule $x(t) = x_0 + v_o t + at^2/2$ ; puisque l'on connait maintenant les termes pour $x_0$, $v_0$ et a, on les remplace simplement dans l'expression pour trouver la distance : $x(t) = (- 250 + 20t + 1.5t^2/2)m$.
Le dépassement est terminé à t = 9s, pour trouver la distance parcourue, on calcule $x(9) = (- 250 + 20\cdot 9 + 1.5\cdot 9^2/2)m = -9.25m$ Le dépassement est donc terminé peu avant le rétrécissement !

**Exercice 2 :**

A) Il s'agit d'un mouvement circulaire uniforme. Puisque nous avons la période de rotation (T = 5s) et le rayon (r = 8m), nous pouvons utiliser la formule $v = 2\pi r/T$ pour trouver la vitesse tangentielle : $v = 2\pi r/T = v = 2\pi\cdot 8/5 = 10m/s$

B) Ici on connait la fréquence, sachant que $T = 1/f$, on peut utiliser la formule $v = 2\pi rf$ pour trouver la nouvelle vitesse tangentielle : $v = 2\pi rf = 2\pi\cdot 8\cdot 0.3 = 15m/s$.

C) On peut soit utiliser les formules $\omega = 2\pi/T = 2\pi f$ avec les données de l'exercices, soit utiliser $\omega = v/r$ avec les résultats obtenus. On obtient ainsi $\omega_A = 1.26rad/s$ et $\omega_B = 1.89rad/s$.