1.
Speed is 36 km/h.
Convert km/h to m/s.
*****
1 km = 1000 m
1 h = 60 min · 60 s

υ=36 (km/h) = $\frac{36\cdot1000}{60\cdot60}$ = 10 (m/s).

2.
The length of the vectors $\vec{A}$ is 2, $\vec{B}$ is $\sqrt{2}$, the angle between them is 45º.
Find the scalar product.
*****
$\vec{A}\cdot\vec{B} = |\vec{A}|\cdot|\vec{B}|\cdot\cos(\Theta_{AB})=2\cdot\sqrt{2}\cdot\frac{\sqrt{2}}{2} = 2$

3.
The body moves equally slowly (a<0).
Acceleration is 2 m/s^2, starting speed is 50 m/s, driving time is 10 s.
Find the final speed.
*****
$\upsilon_f = \upsilon_i + a\cdot t$ = 50 – 2·10 = 30 (m/s).

4.
The body moves equally accelerated (a>0) and passed 100 m in 2 s.
Starting speed is 30 m/s.
Find the acceleration.
*****
$S = \upsilon_i \cdot t + \frac{a\cdot t^2}{2}$
$a = \frac{(S-\vartheta_i\cdot t)\cdot 2}{t^2} = \frac{(100-30\cdot2)\cdot2}{2^2}$ = 20 (m/s^2).

5.
The force F_1 is 50 N, the force F_2 is 30 N.
The forces are directed towards each other.
The body mass is 2 kg.
Find acceleration.
*****
Second Newton’s low:
$\sum_i \vec{F_i} = m\cdot\vec{a}$

$a = \frac{F_1-F_2}{m} = \frac{50-30}{2}$ = 10 (m/s^2).

6.
A mass m (10 kg) hangs on a spring with spring constant k (200 N/m).
Find the amount Δx by which the string is stretched when the mass is at rest in static force equilibrium.
*****
Second Newton's low:
$\sum_i \vec{F_i} = m \cdot \vec{a}$
a=0
$m \cdot g - k \cdot \Delta x = 0$

$\Delta x = \frac{m \cdot g}{k} = \frac{10 \cdot 9.8}{200} = 0.49$ (m)

7.
A body (mass m is 5 kg) is at a height h of 2 m.
Find his potential energy U.
*****
$U = m \cdot g \cdot h = 5 \cdot 9.8 \cdot 2 = 98$ (J).

8.
A body fell down from a height h of 20 m.
Find its speed in the second degree (υ^2) at the moment of collision with the ground.
*****
The principle of the conservation of mechanical energy:
$K + U = A$
A is work of conservative forces: $A = 0$.
$K_i + U_i = K_f + U_f$
$K_i = 0$
$U_i = m \cdot g \cdot h$
$K_f = \frac{m \cdot \vartheta^2}{2}$
$U_f = 0$
$0 + m \cdot g \cdot h = \frac{m \cdot \vartheta^2}{2} + 0$
$\vartheta^2 = 2 \cdot g \cdot h = 2 \cdot 9.8 \cdot 20 = 392$ (m^2/s^2)

9.
A power is 1492 W.
Convert W to Horspower (HP).
*****
1 HP = 746 W
P = 1492 W = $\frac{1492}{746}$ = 2 (HP)

10.
A 100-watt lamp work 30 seconds.
Find the energy spent.
*****
$P = \frac{W}{t}$
$W = P \cdot t = 100 \cdot 30 = 3000$ (J).

11.
A body moves at a speed υ (100 m/s) under the action of the force F (5 N).
The directions of velocity and force coincide.
Find the power of this process.
*****
$P = F \cdot \upsilon = 5 \cdot 100 = 500$ (W)

12.
Two bodies are at a distance r_1 and have a gravitational attraction F_1.
Find the gravitational attraction F_2 between the same bodies, if the distance is increased by 2 times.
*****
Universal gravitational law:
$F = \mathrm{G} \cdot \frac{m \cdot M}{r^2}$
$F_1 = \mathrm{G} \cdot \frac{m \cdot M}{r_1^2}$
$F_2 = \mathrm{G} \cdot \frac{m \cdot M}{r_2^2}$
$\frac{F_2}{F_1} = \frac{r_1^2}{r_2^2}$
$r_2 = 2 \cdot r_1$
$\frac{F_2}{F_1} = \frac{r_1^2}{(2 \cdot r_1)^2} = 1/4$
$F_2 = F_1/4$

13.
A ball (mass is 1 kg) slides at a speed of 5 m/s.
Find the momentum.
*****
$p = m \cdot v = 1 \cdot 5 = 5$ (kg·m/s)

14.
A point particle (mass is 1 kg) moves in a circle with radius of 2 m with angular acceleration 5 rad/s^2.
Find the torque.
*****
$\tau = I \cdot \alpha$
The moment of inertia $I = m \cdot R^2$
$\tau = m \cdot R^2 \cdot \alpha = 1 \cdot 2^2 \cdot 5 = 20$ (N·m)

15.
A first goods (mass m_1 is 2 kg) lies on the left shoulder (radius R_1 is 1 m) of see-saw.
A second goods (mass m_2) lies on the right shoulder (radius R_2 is 2 m).
The see-saw is in balance.
Find mass m_2 .
*****
$m_1 \cdot g \cdot R_1 = m_2 \cdot g \cdot R_2$
$m_2 = \frac{m_1 \cdot R_1}{R_2} = \frac{2 \cdot 1}{2} = 1$ (kg)

16.
A child (mass m is 20 kg) descends a 5 m high and reaches the bottom with a speed 2 m/s.
How much thermal energy (Th) due to friction was generated in this process?
*****
Generalized non-conservative work-mechanical energy theorem:
$U_i + K_i = U_f + K_f + Th$
$U_i = m \cdot g \cdot h \quad K_i = 0$
$U_f = 0 \quad K_f = \frac{m \cdot \vartheta^2}{2}$
$m \cdot g \cdot h + 0 = 0 + \frac{m \cdot \vartheta^2}{2} + Th$
$Th = m \cdot g \cdot h - \frac{m \cdot \vartheta^2}{2} = 20 \cdot 9.8 \cdot 5 - \frac{20 \cdot 2^2}{2} = 980 – 400 = 580$ (J)

17.
First ball (mass m_1 is 2 kg) moving east with a speed of 10 m/s collides head-on with second ball (mass m_2 is 1 kg) puck initially at rest.
Find velocity (speed and direction) of each ball after perfectly elastic collision.
*****
$m_1 \cdot \overrightarrow{\vartheta_1} + 0 = m_1 \cdot \overrightarrow{U_1} + m_{21} \cdot \overrightarrow{U_2}$ (1)
$\frac{m_1 \cdot \vartheta_1^2}{2} = \frac{m_1 \cdot U_1^2}{2} + \frac{m_2 \cdot U_2^2}{2}$ (2)

Suppose that both balls move east after a collision.
$U_1 \geq 0$, $U_2 \geq 0$
=> $m_1 \cdot \vartheta_1 = m_1 \cdot U_1 + m_{21} \cdot U_2$ (1)
$U_2 = \frac{m_1 \cdot \vartheta_1 - m_1 \cdot U_1}{m_2}$ -> (2)
=> $\frac{m_1 \cdot \vartheta_1^2}{2} = \frac{m_1 \cdot U_1^2}{2} + \frac{m_2 \cdot (m_1 \cdot \vartheta_1 - m_1 \cdot U_1)^2}{2 \cdot m_2^2}$
$\vartheta_1^2 = U_1^2 + \frac{m_1}{m_2} \cdot \vartheta_1^2 - \frac{m_1}{m_2} \cdot 2 \cdot \vartheta_1 \cdot U_1 + \frac{m_1}{m_2} \cdot U_1^2$
$3 \cdot U_1^2 - 40 \cdot U_1 + 100 = 0$
Epy equation solution:
1) $U_1 = 10$; $U_2 = 0$; mathematically only
2) $U_1 = 10/3$; $U_2 = 13\ 1/3$
Ans.: $U_1 = 10/3$ (m/s) east ; $U_2 = 13\ 1/3$ (m/s) east.