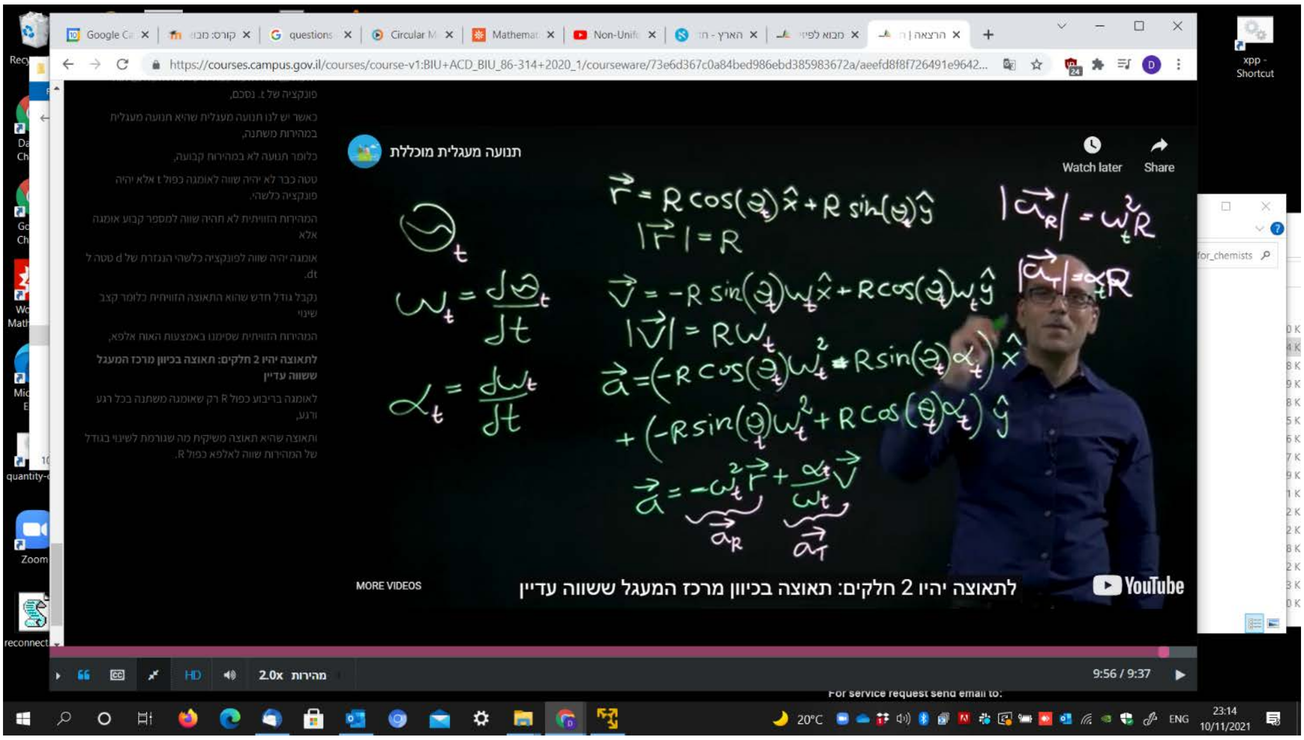
Question 1

This picture is taken from the MOOC.



Solutions for questions taken from the Halliday and Resnick book.

Question 2

49. We refer to the discussion in the textbook (see Sample Problem – "Conservation of momentum, ballistic pendulum," which uses the same notation that we use here) for many of the important details in the reasoning. Here we only present the primary computational step (using SI units):

$$v = \frac{m+M}{m}\sqrt{2gh} = \frac{2.010}{0.010}\sqrt{2(9.8)(0.12)} = 3.1\times10^2 \text{ m/s}.$$

Question 3

34. Let $\vec{F}_N$ be the normal force of the ice on him and m is his mass. The net inward force is $mg\cos\theta - F_N$ and, according to Newton's second law, this must be equal to mv^2/R, where v is the speed of the boy. At the point where the boy leaves the ice $F_N = 0$, so $g\cos\theta = v^2/R$. We wish to find his speed. If the gravitational potential energy is taken to be zero when he is at the top of the ice mound, then his potential energy at the time shown is

$$U = -mgR(1 - \cos\theta).$$

He starts from rest and his kinetic energy at the time shown is $\frac{1}{2}mv^2$. Thus conservation of energy gives

$$0 = \tfrac{1}{2}mv^2 - mgR(1-\cos\theta),$$

or $v^2 = 2gR(1 - \cos\theta)$. We substitute this expression into the equation developed from the second law to obtain $g\cos\theta = 2g(1 - \cos\theta)$. This gives $\cos\theta = 2/3$. The height of the boy above the bottom of the mound is

$$h = R\cos\theta = \frac{2}{3}R = \frac{2}{3}(13.8 \text{ m}) = 9.20 \text{ m}.$$

Question 4

22. We use d to denote the magnitude of the spelunker's displacement during each stage. The mass of the spelunker is m = 80.0 kg. The work done by the lifting force is denoted W_i where i = 1, 2, 3 for the three stages. We apply the work-energy theorem, Eq. 17-15.

(a) For stage 1, $W_1 - mgd = \Delta K_1 = \frac{1}{2}mv_1^2$, where $v_1 = 5.00\ \text{m/s}$. This gives

$$W_1 = mgd + \frac{1}{2}mv_1^2 = (80.0\ \text{kg})(9.80\ \text{m/s}^2)(10.0\ \text{m}) + \frac{1}{2}(80.0\ \text{kg})(5.00\ \text{m/s})^2 = 8.84\times10^3\ \text{J}.$$

(b) For stage 2, $W_2 - mgd = \Delta K_2 = 0$, which leads to

$$W_2 = mgd = (80.0\ \text{kg})(9.80\ \text{m/s}^2)(10.0\ \text{m}) = 7.84\times10^3\ \text{J}.$$

(c) For stage 3, $W_3 - mgd = \Delta K_3 = -\frac{1}{2}mv_1^2$. We obtain

$$W_3 = mgd - \frac{1}{2}mv_1^2 = (80.0\ \text{kg})(9.80\ \text{m/s}^2)(10.0\ \text{m}) - \frac{1}{2}(80.0\ \text{kg})(5.00\ \text{m/s})^2 = 6.84\times10^3\ \text{J}.$$

Question 5

A.

11. When displaced from equilibrium, the net force exerted by the springs is $-2kx$ acting in a direction so as to return the block to its equilibrium position ($x = 0$). Since the acceleration $a = d^2x/dt^2$, Newton's second law yields

$$m\frac{d^2x}{dt^2} = -2kx.$$

Substituting $x = x_m \cos(\omega t + \phi)$ and simplifying, we find $\omega^2 = 2k/m$, where ω is in radians per unit time. Since there are 2π radians in a cycle, and frequency f measures cycles per second, we obtain

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{2k}{m}} = \frac{1}{2\pi}\sqrt{\frac{2(7580 \text{ N/m})}{0.245 \text{ kg}}} = 39.6 \text{ Hz}.$$

B. Assuming the springs are not stretched at rest:

$$U = E_K = 2\frac{1}{2}k(\Delta x)^2 = k(\Delta x)^2$$

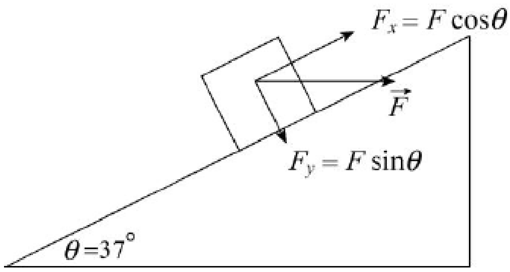
C.

$$\Delta x(t) = A\cos(\omega t + \phi)$$
$$v(t) = -A\omega\sin(\omega t + \phi)$$
$$t = 0:$$
$$\Delta x(0) = A\cos\phi$$
$$v(0) = -A\omega\sin\phi$$
$$v(0)/\Delta x(0) = -\omega\tan\phi$$
$$\phi = \arctan(-v(0)/(\Delta x(0)\omega)) \quad -\pi/2 \le \phi < 0$$
$$A = \Delta x(0)/\cos\phi$$

Question 6

98. We resolve this horizontal force into appropriate components.

(a) Applying Newton's second law to the x (directed uphill) and y (directed away from the incline surface) axes, we obtain



$$F\cos\theta - f_k - mg\sin\theta = ma$$
$$F_N - F\sin\theta - mg\cos\theta = 0.$$

Using $f_k = \mu_k F_N$, these equations lead to

$$a = \frac{F}{m}(\cos\theta - \mu_k \sin\theta) - g(\sin\theta + \mu_k \cos\theta)$$

which yields $a = -2.1$ m/s^2, or $|a| = 2.1$ m/s^2, for $\mu_k = 0.30$, $F = 50$ N and $m = 5.0$ kg.

(b) The direction of $\vec{a}$ is down the plane.

(c) With $v_0 = +4.0$ m/s and $v = 0$, Eq. 2-16 gives $\Delta x = -\frac{(4.0\text{ m/s})^2}{2(-2.1\text{ m/s}^2)} = 3.9$ m.

(d) We expect $\mu_s \geq \mu_k$; otherwise, an object started into motion would immediately start decelerating (before it gained any speed)! In the minimal expectation case, where $\mu_s = 0.30$, the maximum possible (downhill) static friction is, using Eq. 6-1,

$$f_{s,\max} = \mu_s F_N = \mu_s (F\sin\theta + mg\cos\theta)$$

which turns out to be 21 N. But in order to have no acceleration along the x axis, we must have

$$f_s = F\cos\theta - mg\sin\theta = 10 \text{ N}$$

(the fact that this is positive reinforces our suspicion that $\vec{f}_s$ points downhill). Since the f_s needed to remain at rest is less than $f_{s,\max}$ then it stays at that location.