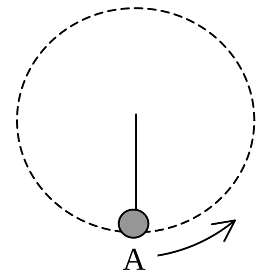
I

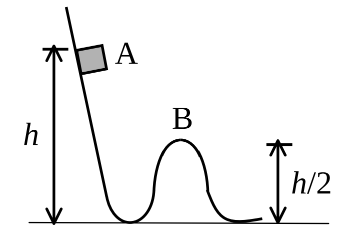
Part I: Questions ***Choose the correct answer***

1. A ball of mass m is connected to one end of a rope and rotates in a **vertical** circle of radius R. If the tension in the rope at point A is T and the speed of the ball at that point is v, then,



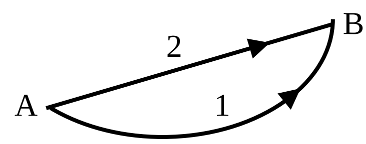
(a) $T = mg$ (b) $T = mv^2/R$ (c) $T = mg + mv^2/R$
(b) $T = mg - mv^2/R$

2. An object slides on a **frictionless surface** between points A and B at heights h and $h/2$, respectively. If its speed at point A equals $\sqrt{gh}$, then its speed at B equals,



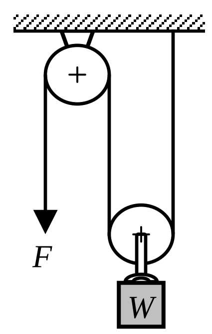
(a) $2\sqrt{gh}$ (b) $\sqrt{2gh}$ (c) $\sqrt{gh}$ (d) $\sqrt{gh/2}$

3. A **conservative force** is applied to a particle as it moves between points A and B. If the work done by this force along paths 1 and 2 equals W_1 and W_2, respectively, then,



(a) $W_1 > W_2$ (b) $W_1 = W_2$ (c) $W_1 = W_2 = 0$
(d) $W_1 = -W_2$

4. The system shown consists of two massless pulleys and a block of weight W. The magnitude of the applied force $\vec{F}$ required to move the weight upward **at constant speed** is,



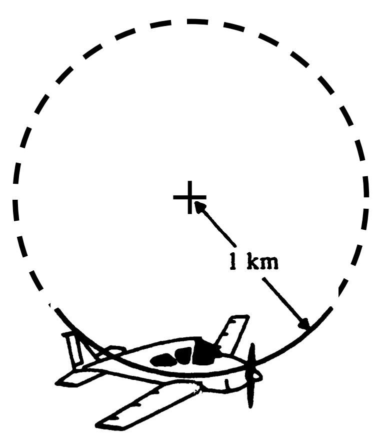
(a) $F = W/3$ (b) $F = 2W$ (c) $F = W$ (d) $F = W/2$

Part II: Problems ***Solve the following problems***

1. A pilot of mass 80 kg drives an airplane in an arc of a vertical circle of radius 1 km as shown in the figure, at a speed of 630 km/h. **Calculate his apparent weight (in N)** at the bottom of the circle.

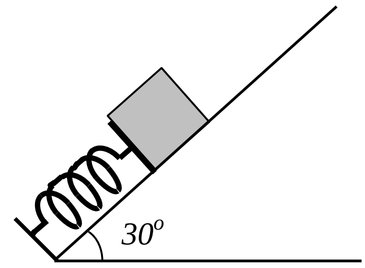
$$N - mg = m\frac{V^2}{R}$$

$$N = m\left(g + \frac{V^2}{R}\right) = (80)\left(10 + \frac{(630/3.6)^2}{1000}\right) = 3250\,N$$



Thus, the apparent weight equals 3250 N

2. A 2.0-kg block is pushed against a spring with a spring constant k = 500 N/m, compressing it 0.30 m. When the block is released, it moves along a **frictionless** 30.0° incline. **How far** (in m) does the block travel up the incline before starting to slide back down?



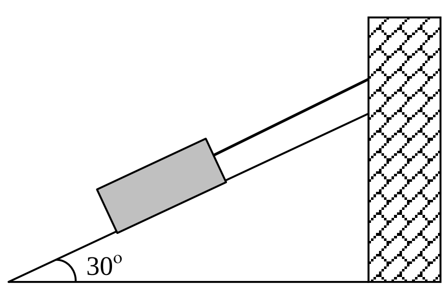
$$E_f = E_i$$

$$E_i = \frac{1}{2}kx^2 = \frac{1}{2}(500)(0.3)^2 = 22.5J$$

$$E_f = mgd\sin\theta$$

$$d = \frac{E_i}{mg\sin\theta} = \frac{22.5}{10} = 2.25m$$

3. A block is held by a rope on a rough 30° incline as shown in the figure. The coefficient of static friction between the block and the incline, μ_s=0.4. The rope withstands a tension force up to 100 N without being cut. **What is the maximum weight of the block (in N) to avoid cutting the rope?**



$$W\sin\theta - T - f_{s\max} = 0$$

$$f_{s\max} = \mu_s N = \mu_s W\cos\theta$$

$$T = W\sin\theta - \mu_s W\cos\theta$$

$$W = \frac{T}{\sin\theta - \mu_s\cos\theta} = \frac{(100)}{(0.5)-(0.4)(0.866)} \approx 651N$$

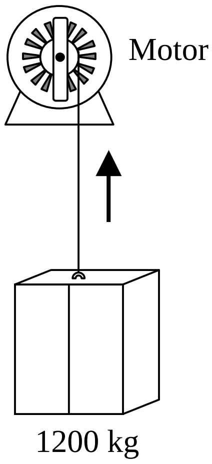
4. An elevator of mass 1200 kg is required to travel 50 m upward in 30 s, starting and ending at rest. **Find the average power (in W) that must be delivered by the motor**.

$$\Delta K = W_g + W_{motor} = 0$$

$$W_g = -mgh = -(1200)(10)(50) = -600KJ$$

$$W_{motot} = -W_g = +600KJ$$

$$P_{motor} = \frac{W_{motor}}{\Delta t} = \frac{600000}{30} = 20000W$$



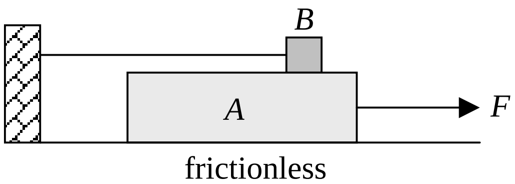
5. Block A of mass 5 kg is placed on a frictionless horizontal surface. Block *B* of mass 1 kg is placed on top of block A and is connected to the wall by a string as shown in the figure. A force *F* of magnitude 14 N is required to pull block *A* to the right with an acceleration of 2 m/s^2. Find the coefficient of kinetic friction between the two blocks.

$$F - f_k = m_A a$$

$$f_k = F - m_A a = 14 - 10 = 4N$$

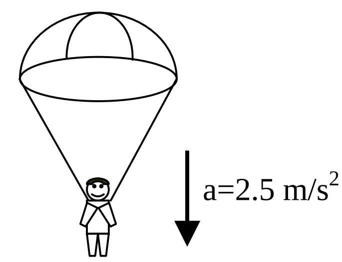
$$f_k = \mu_k m_B g$$

$$\mu_k = \frac{f_k}{m_B g} = 0.4$$



6. An 80-kg person is parachuting and experiencing a downward acceleration of 2.5 m/s^2. **Find the force (in N) that the person exerts on the parachute**.

Let m be the mass of the man and ρ is the upward force exerted on the man by the parachute, then



$$mg - \rho = ma$$

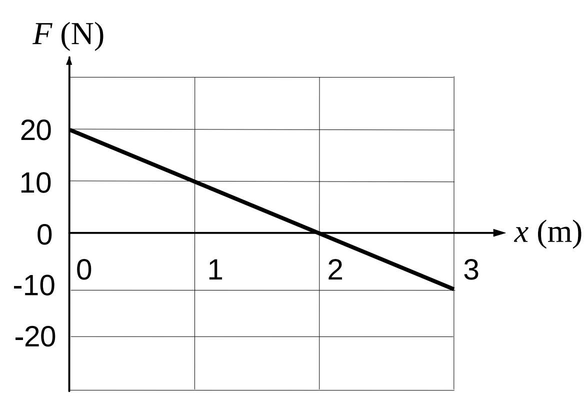
$$\rho = mg - ma = (80)(10) - (80)(2.5) = 600N$$

7. A single conservative force acting on a particle changes with position as shown in the figure. If the potential energy U associated with this force equals 20 J at x = 0, **find the value of U (in J) at x = 3m**.

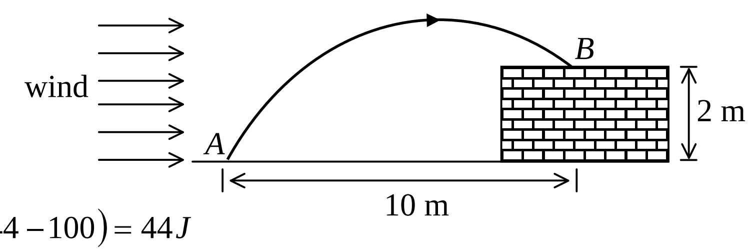
$$\Delta U = -W_F$$

$$W_F = \int_0^3 F(x)dx = (0.5)(2)(20) - (0.5)(1)(10) = 15J$$

$$U(3m) = U(0) - W_F = 20 - 15 = 5J$$



8. A 2-kg projectile is launched at point *A* with an initial speed of 10 m/s then hits the ground at point B with a speed of 12 m/s. The wind blowing in the east direction exerts a **constant force** on the projectile along its path. **Find the work done by the wind on the projectile**.



$$\Delta K = W_g + W_w$$

$$W_g = -mgh = -(20)(2) = -40\,J$$

$$\Delta K = \frac{1}{2}m\left(V_B^2 - V_A^2\right) = \left(\frac{1}{2}\right)(2)(144-100) = 44\,J$$

$$W_w = \Delta K - W_g = 44 - (-40) = 84\,J$$