Final 072

Q1.

A ball is thrown straight up and is caught 2.00 s later at the same point. The initial speed of the ball is:

A) 9.80 m/s
B) 7.40 m/s
C) 4.90 m/s
D) 12.6 m/s
E) 19.6 m/s

$$y = v_0 t - \tfrac{1}{2} g t^2 = 0$$

$$v_0 = \tfrac{1}{2} g t = \tfrac{1}{2}(9.8)\times(2.0) = 9.8\ m/s$$

Q2.
Two points A and B in the x-y plane, A has the coordinates (0 m, 3 m) and B has the coordinates (4 m, 0 m). The displacement vector that goes from A to B is:

A) $\left(4\,\hat{i} - 3\,\hat{j}\right)$ m

B) $\left(3\,\hat{i} - 4\,\hat{j}\right)$ m

C) $\left(4\,\hat{i} + 3\,\hat{j}\right)$ m

D) $\left(-4\,\hat{i} - 3\,\hat{j}\right)$ m

E) $\left(3\,\hat{i} + 4\,\hat{j}\right)$ m

$$\Delta\vec{r} = \Delta x i + \Delta y j = (4-0)i + (0-3)\,j = 4i - 3\,j$$

Q3.

A projectile is fired from the ground with an initial velocity of $\vec{v}_o = \left(3.0\,\hat{i} + 4.0\,\hat{j}\right)$ m/s . Find the velocity of the projectile just before hitting the ground.

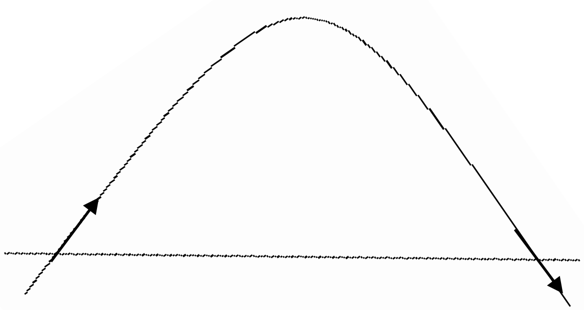
A) $\vec{v} = \left(3.0\,\hat{i} - 4.0\,\hat{j}\right)$ m/s

B) $\vec{v} = \left(-3.0\,\hat{i} + 4.0\,\hat{j}\right)$ m/s

C) $\vec{v} = \left(-3.0\,\hat{i} - 4.0\,\hat{j}\right)$ m/s

D) $\vec{v} = \left(3.0\,\hat{i} + 4.0\,\hat{j}\right)$ m/s

E) $\vec{v} = (5.0)$ m/s



Q4.

Snow is falling vertically at a constant speed of 8.00 m/s relative to the ground. To a driver of a car (travelling horizontally), the snow appears to be falling at an angle of 60.0° from the vertical direction. What is the speed of the car relative to the ground?

A) 13.9 m/s
B) 8.00 m/s
C) 4.00 m/s
D) 6.93 m/s
E) 10.0 m/s

$$v = 8.00 / \tan(30)$$

Q5.

Fig 1 shows two forces, 12.0 N and 15.0 N, acting on a block of mass m = 2.00 kg. The block slides along a rough horizontal table with coefficient of kinetic friction, μ between the block and the table equal to 0.200. Find the acceleration *a* of the block.

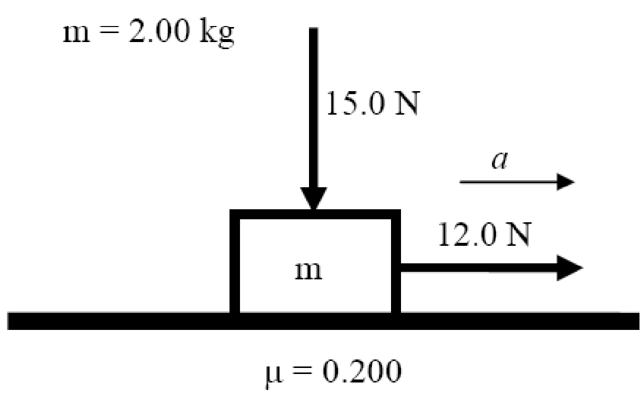
A) 2.54 m/s^2
B) 5.12 m/s^2
C) 7.90 m/s^2
D) 9.89 m/s^2
E) 1.41 m/s^2

$$N = 2\times 9.8 + 15 = 34.6N$$

$$ma = F - \mu N$$

$$2a = 12 - 0.2\times 34.6$$

$$a = 2.54\ m/s^2$$



Q6.

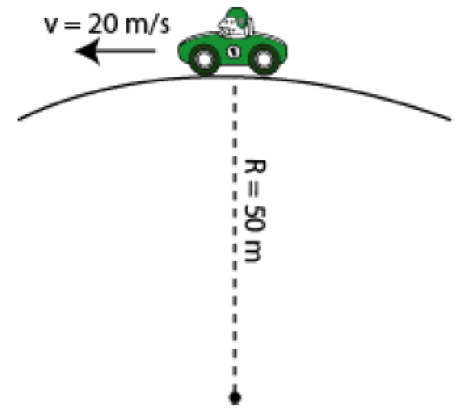
The sum of all the external forces on a block is zero. Which one of the following must be true?

A) The total linear momentum of the block is constant
B) The acceleration of the block in not zero
C) The speed of the block is increasing
D) The block is not in equilibrium
E) The speed of the block is decreasing

$$F = \frac{dP}{dt} = 0 \rightarrow P = \text{constant}$$

Q7.

A 1000 kg car drives over the top of a circular hill that has a radius of R = 50 m. The speed at the top of the hill is v = 20 m/s. Find the normal force on the car at the top of the hill. (see Fig. 2)



A) 1800 N
B) 1000 N
C) 870 N
D) 1500 N
E) 2400 N

$$mg - N = \frac{mv^2}{r}$$

$$N = m(g - \frac{v^2}{r}) = 10^3(9.8 - \frac{400}{50}) = 1800N$$

Q8.

A car has a kinetic energy of 25 J. It then makes a U-turn and moves in the opposite direction with twice the original speed. What is the new kinetic energy of the car?

A) 100J
B) 50J
C) -100J
D) -50J
E) 25J

$$v_f = v_i$$

$$K_f = \tfrac{1}{2}mv^2{}_f = \tfrac{1}{2}m(2v_i)^2 = 4(\tfrac{1}{2}mv^2{}_i) = 4K_i = 4\times 25 = 100\ J$$

Q9.

A 60.0 kg student walks up a hill with constant speed reaching a vertical height of 5.00 m above his initial position. How much work does the gravitational force do on him during this walk?

A) -2940 J
B) 4950 J
C) 2500 J
D) -2500 J
E) 0 J

$$W_g = -W_a = -mgh = -60.0 \times 9.80 \times 5.0 = -2940 \ J$$

Q10.

A 3.0 kg box is given an initial speed of 2.2 m/s on a rough horizontal floor. It stops in 2.0 s due to friction between the box and floor. The work done by the frictional force is:

A) -7.3 J
B) -9.8 J
C) -6.5 J
D) +9.8 J
E) 0 J

$$W_{net} = W_{friction} = \Delta K = K_f - K_i = 0 - \tfrac{1}{2} m v_i^2 = -\tfrac{1}{2} \times 3.0 \times (2.2)^2 = -7.26 J$$

Q11.

A 0.40 kg ball moving with a horizontal velocity $\vec{v}_i = (30\,\hat{i})$ m/s hits a vertical wall and bounces back in the opposite direction with velocity $\vec{v}_f$. If the impact (collision) of the ball with the wall lasts for 0.10 s and the average force of the wall on the ball is $-200\,\hat{i}$ N, find $\vec{v}_f$.

A) $-20\,\hat{i}$ m/s
B) $-30\,\hat{i}$ m/s
C) $+60\,\hat{i}$ m/s
D) $+10\,\hat{i}$ m/s
E) $-15\,\hat{j}$ m/s

$$\overline{F} = \frac{\Delta p}{\Delta t}$$

$$-200i = \frac{1}{0.10}(0.40v_f - 0.40 \times 30i)$$

$$v_f = -20i\ m/s$$

Q12.

Two masses $m_1 = 3.0$ kg $\left(\text{having velocity } \vec{v}_1 = 6.0\,\hat{i} \text{ m/s}\right)$ and $m_2 = 5.0$ kg $\left(\text{having velocity } \vec{v}_2 = -6.0\,\hat{i} \text{ m/s}\right)$ collide and stick together. The final velocity after collision is:

A) $-1.5\,\hat{i}$ m/s

B) $1.5\,\hat{i}$ m/s

C) $2.0\,\hat{i}$ m/s

D) $-0.5\,\hat{i}$ m/s

E) $-2.0\,\hat{i}$ m/s

$$P_i = P_f$$

$$3.0 \times 6.0i + 5.0 \times (-6.0i) = (3.0 + 5.0) \times \vec{V}$$

$$\vec{V} = -1.5i\ m/s$$

Q13.

A wheel rotates at an angular speed of 600 revolutions per minute around its central axis. It has a rotational kinetic energy of 24000 J about this fixed axis. Calculate the rotational inertia of the wheel about this axis.

A) 12 kg·m^2
B) 2.0 kg·m^2
C) 8.5 kg·m^2
D) 14 kg·m^2
E) 10 kg·m^2

$$\omega = \frac{600 \times 2\pi}{60} = 20\pi\ rad/s$$

$$K = \tfrac{1}{2} I \omega^2$$

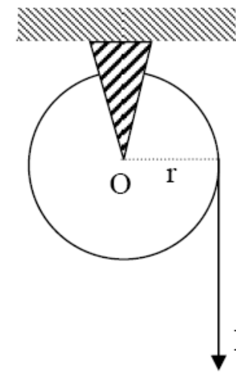
$$24000 = \tfrac{1}{2} I (20\pi)^2$$

$$I = 12\ kg.m^2$$

Q14.

A disk of radius r = 0.10 m has a rotational inertia of 0.020 kg·m^2 about its axis O (see Fig 3). A string is wound around the disk and pulled with a force of 1.4 N. The angular acceleration of the disk is:

A) 7.0 rad/s^2
B) 3.5 rad/s^2
C) 10 rad/s^2
D) 14 rad/s^2
E) 20 rad/s^2



$$\tau = I\alpha$$

$$1.4 \times 0.10 = 0.020 \times \alpha$$

$$\alpha = 7.0\ rad/s^2$$

Q15.
A disk of mass 5.0 kg and radius 0.20 m rolls smoothly on a horizontal floor. If the kinetic energy of rolling of the disk is 70 J at a certain instant, find the speed of the center of mass of the disk. [I_{com}(disk) = ½ MR^2]

A) 4.3 m/s
B) 2.5 m/s
C) 8.0 m/s
D) 40 m/s
E) 0 m/s

$$K_r = \tfrac{1}{2} I\omega^2 = \tfrac{1}{2}(\tfrac{1}{2} mR^2)\times(\frac{v}{R})^2 = \tfrac{1}{4} mv^2$$

$$K_t = \tfrac{1}{2} mv^2$$

$$K = K_r + K_t = \tfrac{1}{4} mv^2 + \tfrac{1}{2} mv^2 = \tfrac{3}{4} mv^2$$

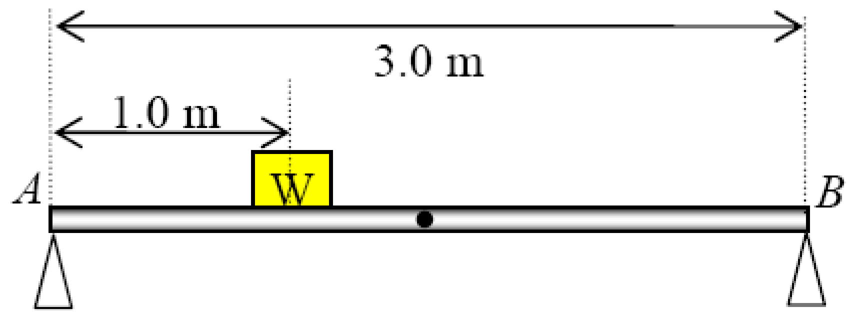
$$70 = \tfrac{3}{4} \times 5.0 v^2$$

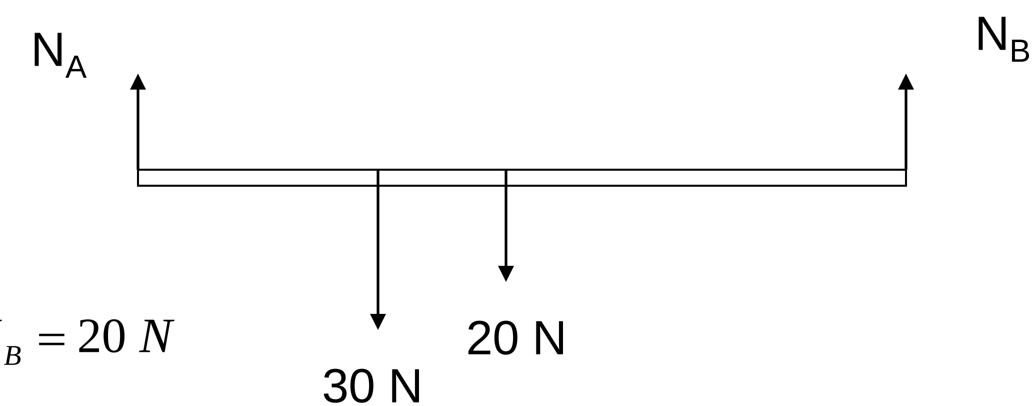
$$v = 4.3\, m/s$$

Q16.

A uniform steel bar of length 3.0 m and weight 20 N rests on two supports (*A* and *B*) at its ends. A block of weight W = 30 N is placed at a distance 1.0 m from *A* (see Fig. 4). The forces on the supports A and B respectively are:

A) 30 N and 20 N
B) 25 N each
C) 40 N and 10 N
D) 35 N and 15 N
E) 50 N each





$$N_A + N_B = 50$$

take the torque around A:

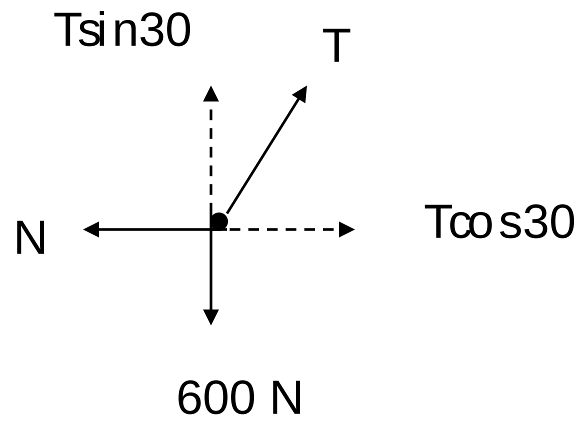
$$30 \times 1.0 + 20 \times \left(\frac{3.0}{2}\right) = N_B \times 3.0 \rightarrow N_B = 20\ N$$

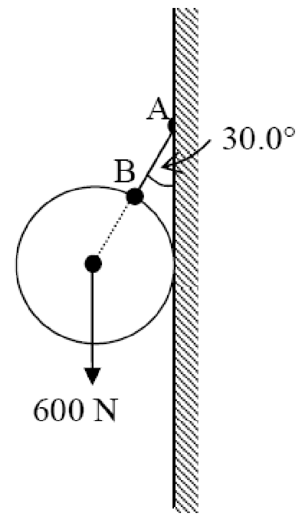
$$N_A = 30\ N$$

Q17.

Fig. 5 shows a uniform ball of 600 N weight suspended by a string AB and rests against a frictionless vertical wall. The string makes an angle of 30.0° with the wall. The magnitude of the tension in the string is:

A) 693 N
B) 346 N
C) 520 N
D) 300 N
E) 600 N





$$600 = T\sin(30) \quad (1)$$

$$N = T\cos(30) \quad (2)$$

$$divide\ (1)/(2)$$

$$\frac{600}{N} = \tan(30)$$

$$N = 693\ N$$

Q18.

A horizontal steel rod of length 81 cm and radius 9.5 mm is fixed at one end. It stretches by 0.90 mm when a horizontal force of magnitude F is applied to its free end. Find the magnitude of F (Young modulus of steel is 20×10^{10} N/m^2).

A) 63 kN
B) 9.8 kN
C) 0.90 kN
D) 2.7 kN
E) 81 kN

$$E = \frac{stress}{strain} = \frac{F/A}{\Delta L / L}$$

$$20 \times 10^{10} = \frac{F \Big/ \left(\pi\left(9.5 \times 10^{-3}\right)^2\right)}{0.90/810}$$

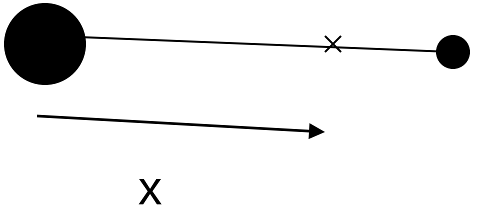
$$F = 63\, kN$$

Q19.

A spaceship is going from the Earth (mass = M_e) to the Moon (mass = M_m) along the line joining their centers. At what distance from the centre of the Earth will the net gravitational force on the spaceship be zero? (Assume that $M_e = 81\ M_m$ and the distance from the centre of the Earth to the center of the Moon is 3.8×10^5 km).

A) 3.4×10^5 km
B) 6.4×10^5 km
C) 2.8×10^5 km
D) 4.7×10^5 km
E) 1.9×10^5 km

$$\frac{GM_e m}{x^2} = \frac{GM_m m}{(d-x)^2}$$



$$\sqrt{\frac{M_e}{M_m}}(d-x) = x$$

$$9(d-x) = x$$

$$9d = 10x$$

$$x = 0.9d = 0.9 \times 3.8 \times 10^5 = 3.4 \times 10^5\,km$$

Q20.
A 1000 kg satellite is in a circular orbit of radius = $2R_e$ about the Earth. How much energy is required to transfer the satellite to an orbit of radius = $4R_e$?
(R_e = radius of Earth = 6.37×10^6 m, mass of the Earth = 5.98×10^{24} kg)

A) 7.8×10^9 J.
B) 6.1×10^9 J.
C) 4.9×10^8 J.
D) 2.4×10^9 J.
E) 1.7×10^8 J.

$$\Delta E = E_f - E_i = -\frac{GM_e m}{2(4R_e)} + \frac{GM_e m}{2(2R_e)} = \frac{GMm}{4R_e}(1 - \tfrac{1}{2})$$

$$\frac{GMm}{8R_e} = 7.8 \times 10^9\ J$$

Q21.

At what altitude above the Earth's surface would the gravitational acceleration be $\frac{a_g}{4}$?

(where a_g is the acceleration due to gravitational force at the surface of Earth and R_e is the radius of the Earth).

A) R_e
B) $2\ R_e$
C) $R_e/2$
D) $R_e/4$
E) $3\ R_e$

$$a = \frac{GM_e}{(R_e + h)^2} = \tfrac{1}{4} a_g = \frac{GM_e}{4R_e^{\ 2}}$$

$$R_e + h = 2R_e \rightarrow h = R_e$$

Q22.

The gravitational acceleration on the surface of a planet, whose radius is 5000 km, is 4.0 m/s^2. The escape speed from the surface of this planet is:

A) 6.3 km/s
B) 2.8 km/s
C) 2.0 km/s
D) 4.0 km/s
E) 8.0 km/s

$$a = \frac{GM}{R^2} = 4.0$$

$$v_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{8R} = \sqrt{8.0 \times 5 \times 10^6} = 6.3\,km$$

Q23.

Water is pumped out of a swimming pool at a speed of 5.0 m/s through a uniform hose of radius 1.0 cm. Find the mass of water pumped out of the pool in one minute. (Density of water = 1000 kg/m^3).

A) 94 kg
B) 0.094 kg
C) 1.6 kg
D) 19 kg
E) 5.1 kg

$$R_m t = Av\rho t = (\pi R^2)\times v\times \rho\times t$$

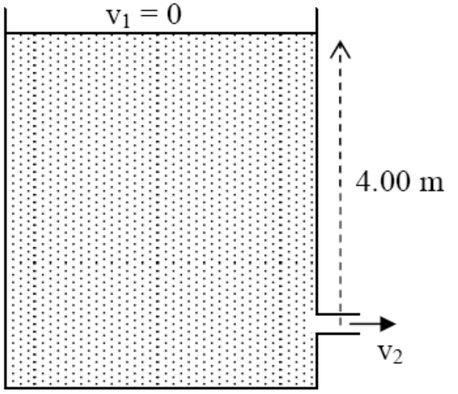
$$= \pi(1.0\times 10^{-4})\times 5.0\times 1000\times 60 = 94\ kg$$

Q24.

A large tank open to atmosphere is filled with water. Fig 6 shows this tank with a stream of water flowing through a hole (open to atmosphere) at a depth of 4.00 m. The speed of water, v_2, leaving the hole is:

A) 8.85 m/s
B) 4.42 m/s
C) 2.21 m/s
D) 17.7 m/s
E) 35.4 m/s

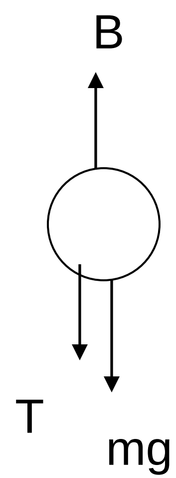
$$v = \sqrt{2gh}$$

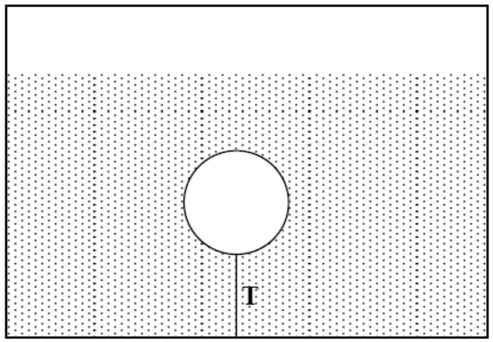


Q25.

A 10 kg spherical object with a volume of 0.10 m^3 is held in static equilibrium under water by a cable fixed to the bottom of a water tank. What is the tension T in the cable? (See Fig. 7)

A) 880 N
B) 980 N
C) 1000 N
D) 1800 N
E) Zero





$$\rho_o = \frac{10}{0.10} = 100\ kg/m^2$$

$$T = B - mg = \rho_f gV - \rho_o gV = Vg(\rho_f - \rho_o)$$

Q26.

A plane is at an altitude of 10,000 m where the outside air pressure is 0.25 atm. If the air pressure inside the plane is 1.0 atm, what is the net outward force on 1m $\times$ 2m door in the wall of the plane?
(1.0 atm = 1.01 $\times$ 10^5 Pa).

A) 1.5 $\times$ 10^5 N
B) 8.5 $\times$ 10^4 N
C) 5.7 N
D) 5.9 $\times$ 10^3 N
E) 1.9 $\times$ 10^{15}N

Q27.

A block of mass 20 g is attached to a horizontal spring with spring constant of 25 N/m. The other end of the spring is fixed. The block is pulled a distance 10 cm from its equilibrium position ($x = 0$) on a frictionless horizontal table and released. The frequency of the resulting simple harmonic motion is:

A) 5.6 Hz
B) 10 Hz
C) -10 Hz
D) 25 Hz
E) 50 Hz

Q28.
A horizontal spring is fixed at one end. A block attached to the other end of the spring undergoes a simple harmonic motion on a frictionless table. Which one of the following statements is correct?

A) The frequency of the motion is independent of the amplitude of oscillation.
B) The frequency of the motion is proportional to the amplitude of oscillation.
C) The acceleration of the block is constant.
D) The maximum speed of the block is independent of the amplitude.
E) The maximum acceleration of the block is independent of the amplitude.

Q29.

A simple pendulum consists of a mass m = 6.00 kg at the end of a light cord of length L. The angle θ between the cord and the vertical is given by $\theta = 0.08\cos\left[\left(4.43\,t + \pi\right)\right]$, where t is in second and θ is in radian. Find the length L.

A) 0.50 m
B) 0.60 m
C) 0.70 m
D) 0.80 m
E) 1.0 m

Q30.
A block attached to an ideal horizontal spring undergoes a simple harmonic motion about the equilibrium position ($x = 0$) with an amplitude $x_m = 10$ cm. The mechanical energy of the system is 16 J. What is the kinetic energy of the block when $x = 5.0$ cm?

A) 12 J
B) 16 J
C) 8.0 J
D) 4.0 J
E) 32 J