Q1.

Work is defined as the scalar product of force and displacement. Power is defined as the rate of change of work with time. The dimension of power is:

A) ML^2T^{-3}
B) $M^2L^2T^3$
C) $ML^{-1}T^{-2}$
D) $M^2L^2T^2$
E) $ML^{-1}T^{-1}$

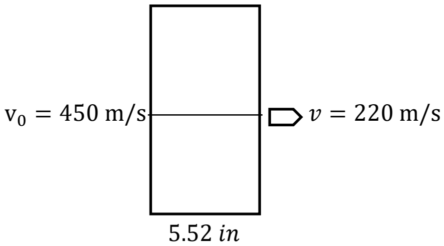
Ans:

$$P = \frac{W}{t} = \frac{F\Delta X}{t} = \frac{ML}{T^2}\frac{L}{T} = ML^2T^{-3}$$

Q2.

A bullet is fired through a wooden board, 5.52 inches thick, with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m/s and emerges with a speed of 220 m/s, what is the bullet's acceleration as it passes through the board? (Assume the acceleration is constant and take 1 inch = 2.54 cm.)

A) −550 km/s²
B) +360 km/s²
C) −360 km/s²
D) +550 km/s²
E) +275 km/s²



Ans:

$$v^2 = v_0^2 + 2a\Delta x$$

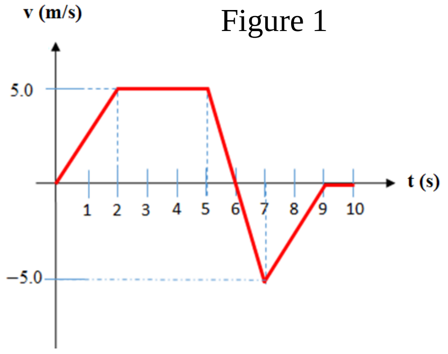
$$a = \frac{v^2 - v_0^2}{2\Delta x} = \frac{(250)^2 - (450)^2}{2 \times 5.52 \times 2.54 \times 10^{-2}} = 550 km/s^2$$

Q3.

A person pushes a cart along a straight track. The velocity of the cart changes over time as shown in **Figure 1**. What is the average acceleration of the cart between t = 2 s and t = 7 s?

A) -2.0 m/s^2
B) -3.5 m/s^2
C) $+2.0$ m/s^2
D) $+3.5$ m/s^2
E) zero

Figure 1



Ans:

$$a = \frac{\Delta v}{\Delta t} = \frac{v(7) - v(2)}{7 - 2}$$

$$a = \frac{-5 - 5}{5} = \frac{-10}{5} = -2\ m/s^2$$

Q4.

A rock is dropped vertically down from rest from the top of a 100-m high building. At what time and with what speed will the rock reach 50.0 m below the top of the building? (Ignore air resistance)

A) 3.18 s, 31.3 m/s
B) 1.50 s, 19.8 m/s
C) 4.36 s, 24.5 m/s
D) 3.18 s, 11.6 m/s
E) 9.80 s, 59.1 m/s

Ans:

$$v_0 = 0$$

$$\Delta y = -50\ m$$

$$a = -9.8\ m/s^2$$

$$\Delta y = \frac{1}{2} a t^2$$

$$t = \sqrt{\frac{2\Delta y}{a}} = \sqrt{\frac{2 \times (-50)}{-9.8}} = 3.2\ s$$

$$v^2 = v_0^2 + 2a\Delta y \quad (v_0^2 = 0)$$

$$v = \sqrt{2a\Delta y} = \sqrt{2 \times (-9.8)(-50)} = 31.3\ m/s$$

Q5.

The position of a particle moving along the x axis is given by: $x = 2.0 + 6.0t^2 - 2.0t^3$ (in SI units). Find the magnitude of the acceleration at the instant when the particle reaches the maximum position along the positive x-axis.

A) 12 m/s^2
B) 6.0 m/s^2
C) 24 m/s^2
D) 18 m/s^2
E) zero

Ans:

$$x = 2 + 6t^2 - 2t^3$$

$$v(t) = \frac{dx}{dt} = 12t - 6t^2$$

$$At\ maximum\ position, v(t) = 0$$

$$12t - 6t^2 = 0 \Rightarrow t = 2s$$

$$a(t) = \frac{dv(t)}{dt} = 12 - 12\,t$$

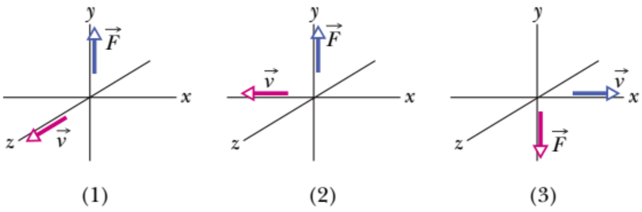
$$a(2) = 12 - 12 \times 2 = -12\ m/s^2$$

$$a(2) = 12\ m/s^2$$

Q6.

A vector $\vec{F}$ is given as $\vec{F} = q(\vec{v} \times \vec{B})$, where $\vec{v}$ is perpendicular to $\vec{B}$. In which of the situations, shown in **Figure 2**, is the direction of $\vec{B}$ in the positive z-axis if q is a positive constant?

Figure 2



A) 2 and 3 only
B) 1 only
C) 2 only
D) 3 only
E) 1 and 3 only

Ans:

$$\boldsymbol{F} = q(\boldsymbol{v} \times \boldsymbol{B})$$

For (3): $-\hat{j} = +(\hat{\imath} \times \hat{k})$

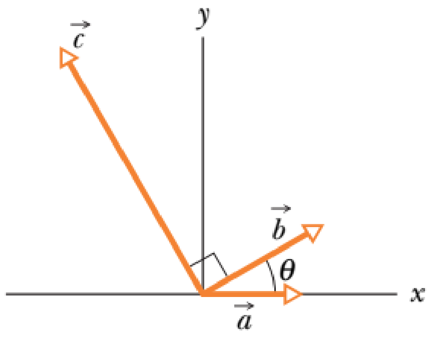
For (2): $\hat{j} = (-\hat{\imath} \times \hat{k})$

Q7.

The three vectors in **Figure 3** have magnitudes a = 3.00 m, b = 4.00 m, and c = 10.0 m and angle θ = 30.0°. If $\vec{c} = p\vec{a} + q\vec{b}$, what are the values of p and q, respectively?

A) −6.66 and 4.33
B) −5.00 and 8.66
C) 3.00 and −5.00
D) −2.44 and −3.55
E) 12.5 and 9.86

Figure 3



Ans:

$\vec{a} = 3\,\hat{\imath}$

$\vec{b} = 4\,cos30^0\,\hat{\imath} + 4sin30°\,\hat{\jmath}$

$\vec{c} = -10cos60^0\,\hat{\imath} + 10sin60°\,\hat{\jmath}$

$\vec{c} = p\vec{a} + q\vec{b}$

$c_x = pa_x + qb_x$

$-10\,cos60^0 = 3p + 4qcos30°$

$3p + 2\sqrt{3}\,q + 5 = 0$ −−−−−−−−−−−−−−−−−− (1)

$c_y = pa_y + 9b_y$

$10sin60° = 4qsin30°$

$5\sqrt{3} = 2q$

$q = 4.33$

$Using\ value\ of\ q\ in\ equation\ (1)$

$p = -6.66$

Q8.

Starting from origin O, a camel walks 25 km south of west ($\vec{d}_1$) and reaches to point A as shown in **Figure 4**. Then it walks 30 km directly up to the north ($\vec{d}_2$) and reaches to point B. If point B is 28 km away from the origin, find the angle (θ) between $\vec{d}_1$ and $\vec{d}_2$.

A) 120°
B) 150°
C) 105°
D) 130°
E) 159°

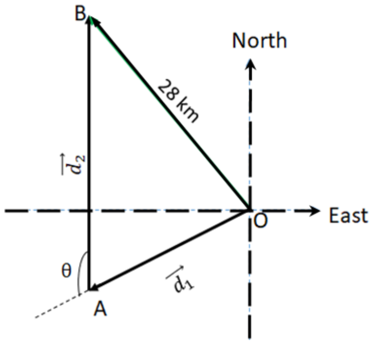


Figure 4

Ans:

$$(\vec{d}_1+\vec{d}_2)\cdot(\vec{d}_1+\vec{d}_2)=\left|\vec{d}_1+\vec{d}_2\right|^2$$

$$\left|\vec{d}_1\right|^2+2\left|\vec{d}_1\right|\left|\vec{d}_2\right|cos\theta+\left|\vec{d}_2\right|^2=\left|\vec{d}_1+\vec{d}_2\right|^2$$

$$(25)^2+2\times 25\times 30cos\theta+(30)^2=28^2$$

$$\theta=\cos^{-1}\left(\frac{28^2-25^2-30^2}{2\times 25\times 30}\right)=120°$$

Q9.

A particle moves in the *xy* plane, starting from the origin at $t = 0$ with an initial velocity $\vec{v}_0 = 20.0\hat{i} - 3.00\hat{j}$, where the unit of velocity is m/s. The particle experiences an acceleration in the *x* direction only that is given by $a_x = -4.00$ m/s^2. Find the magnitude of its average velocity from $t = 0$ to $t = 5.00$ s.

A) 10.4 m/s
B) 15.7 m/s
C) 22.5 m/s
D) 35.1 m/s
E) 46.3 m/s

Ans:

$$\Delta x(t)=v_{0x}\Delta t+\frac{1}{2}a_x(\Delta t)^2$$

$$\Delta x(5)=20\times 5-\frac{1}{2}\times 4\times 5^2=50\ m$$

$$\Delta y(5)=v_{0y}\Delta t=-3\times 5=-15\ m$$

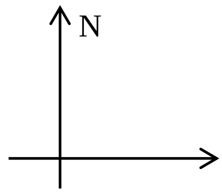
$$v_{av}=\frac{\Delta x}{\Delta t}\hat{\imath}+\frac{\Delta y}{\Delta t}\hat{\jmath}=\frac{50}{5}\hat{\imath}-\frac{15}{5}\hat{\jmath}=10\hat{\imath}-3\hat{\jmath}$$

$$|v_{av}|=\sqrt{10^2+3^2}=10.4\ m/s$$

Q10.

The pilot of an aircraft flies due north relative to the ground in a wind blowing at 40 km/h toward the east. If his speed relative to the ground is 80 km/h, what is the velocity of his airplane relative to the air? (Considering $\hat{\boldsymbol{i}}$ = East and $\hat{\boldsymbol{j}}$ = North)

A) $-40\hat{\boldsymbol{i}}+80\hat{\boldsymbol{j}}$ (km/h)
B) $-40\hat{\boldsymbol{i}}-80\hat{\boldsymbol{j}}$ (km/h)
C) $40\hat{\boldsymbol{i}}+80\hat{\boldsymbol{j}}$ (km/h)
D) $40\hat{\boldsymbol{i}}-80\hat{\boldsymbol{j}}$ (km/h)
E) $40\hat{\boldsymbol{i}}+40\hat{\boldsymbol{j}}$ (km/h)



W=Wind

A=Airplane

E=Earth

Ans:

$$v_{AE} = 80\,\hat{j}$$

$$v_{WE} = 40\,\hat{\imath}$$

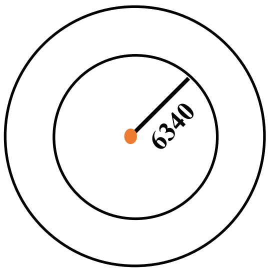
$$v_{AW} = v_{AE} - v_{WE}$$

$$v_{AW} = 80\hat{j} - 40\hat{\imath} = -40\hat{\imath} + 80\hat{j}\ (km/h)$$

Q11.

An Earth satellite moves in a circular orbit of radius 7010 km with a period of 98 min. What is the magnitude of the centripetal acceleration of the satellite?

A) 8.0 m/s^2
B) 5.0 m/s^2
C) 3.0 m/s^2
D) 2.0 m/s^2
E) 4.0 m/s^2



Radius of Earth = 6340 km

Ans:

$$v = \frac{2\pi R}{T}$$

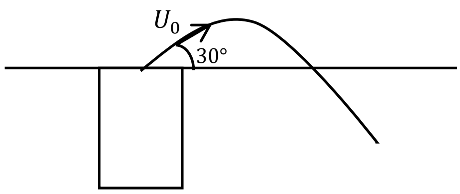
$$a = \frac{v^2}{R} = \frac{4\pi^2 R^2}{T^2 R} = \frac{4\pi^2 R}{T^2}$$

$$a = \frac{4 \times 3.14^2 \times 7010 \times 10^3}{98 \times 60} = 8\ m/s^2$$

Q12.

A stone is thrown from the top of a building at an angle of 30° above the horizontal with an initial speed of 20 m/s. The height from which the stone is thrown is 45 m above the ground. What is the final speed of the stone just before it hits the ground? (Ignore air resistance)

A) 36 m/s
B) 20 m/s
C) 15 m/s
D) 43 m/s
E) 54 m/s



Ans:

$$v_0 = 20\ m/s$$

$$v_x = 20\ cos30° = 17.3\ m/s\ \ (constant)$$

$$v_{0y} = 20sin30° = 10\ m/s$$

$$a = -9.8\ m/s^2$$

$$\Delta y = -45\ m$$

$$v_y = \sqrt{v_{oy}^2 + 2a\Delta y} = 31.3\ m/s$$

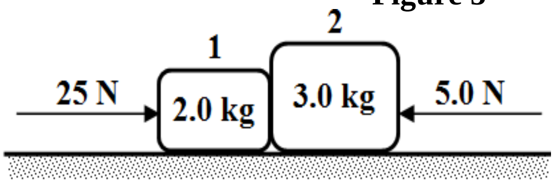
$$|v| = \sqrt{v_x^2 + v_y^2} = 35.8\ m/s$$

Q13.

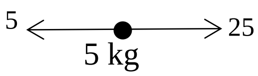
Two blocks of masses 2.0 kg and 3.0 kg move on a horizontal frictionless surface and are subjected to two horizontal forces of magnitudes 25 N and 5.0 N, respectively, as shown in **Figure 5**. What is the magnitude of the force exerted by block 2 on block 1?

A) 17 N
B) 21 N
C) 29 N
D) 37 N
E) 11 N

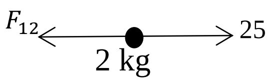
Figure 5



Ans:



$$25 - 5 = 5a \Rightarrow a = 4\ m/s^2$$



$$25 - F_{12} = 2a \Rightarrow F_{12} = 25 - 2 \times 4 = 17\ N$$

Q14.

A block is projected up a frictionless inclined plane with initial speed v_o = 3.50 m/s. The angle of the inclined plane is θ = 32.0°. How far up the plane does the block go?

A) 1.18 m
B) 2.91 m
C) 5.27 m
D) 6.34 m
E) 3.75 m

Ans:

$v = 0$

$a = -9.8\, sin32°$

$v_0 = 3.5$

$\Delta l = ?$

$v^2 = v_0^2 + 2a\Delta l$ (with $v^2 \to 0$)

$$\Delta l = -\frac{v_0^2}{2a} = \frac{3.5^2}{2 \times 9.8 sin32} = 1.18\ m$$

Q15.

Using a rope that will break completely if the tension in it exceeds 600 N, you need to lift vertically a block weighing 449 N from the ground. What magnitude of acceleration will put the rope on the verge of breaking?

A) 3.3 m/s^2
B) 1.4 m/s^2
C) 7.5 m/s^2
D) 4.6 m/s^2
E) 9.1 m/s^2

Ans:

$T - mg = ma$

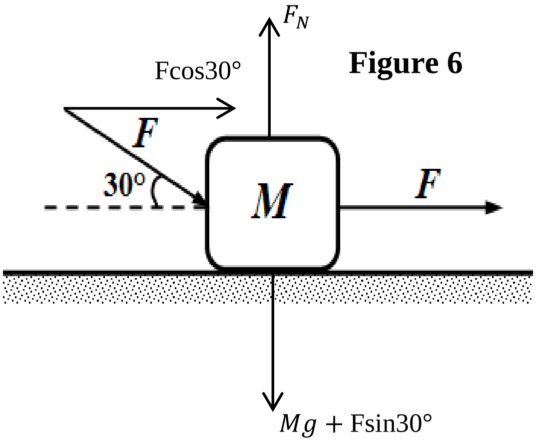
$$a = \frac{600 - 449}{(449/9.8)} = 3.3\ m/s^2$$

Q16.

A block slides on a frictionless horizontal surface under the action of two forces, as shown in **Figure 6**. If ***F*** = 20 N and *M* = 5.0 kg, find the magnitudes of the resulting acceleration of the block and the normal force on the block, respectively.

A) 7.5 m/s^2 and 59 N
B) 7.5 m/s^2 and 84 N
C) 4.5 m/s^2 and 47 N
D) 4.5 m/s^2 and 59 N
E) 3.0 m/s^2 and 84 N

Figure 6



Ans:

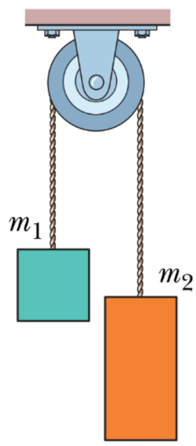
$$F_N = mg + Fsin30°$$
$$= 5 \times 9.8 + 20sin30°$$
$$= 49 + 10 = 59\ N$$
$$F + Fcos30° = ma$$
$$a = \frac{20\left(1 + \frac{\sqrt{3}}{2}\right)}{5} = 7.5\, m/s^2$$

Q17.

A massless rope passes over a massless and frictionless pulley suspended from the ceiling as shown in **Figure 7**. A block of mass m_1 = 4 kg is attached to one end, and another block of mass m_2 = 5 kg is attached to the other end. The acceleration of the 5-kg block is:

A) *g/9*
B) *5g/9*
C) *4g/9*
D) *g/5*
E) *g/4*

Figure 7



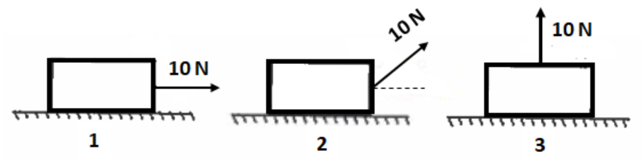
Ans:

$$T - m_1 g = m_1 a \Rightarrow T = m_1(a + g)$$
$$T - m_2 g = -m_2 a \Rightarrow T = m_2(g - a)$$
$$m_1 a + m_1 g = m_2 g - m_2 a$$
$$(m_1 + m_2)a = (m_2 - m_1)g$$
$$a = \frac{(m_2 - m_1)}{(m_1 + m_2)} g = \left(\frac{5 - 4}{5 + 4}\right) g = \frac{g}{9}$$

Q18.

A crate rests on a rough horizontal surface and a person pulls on it with a 10-N force. No matter what the orientation of the force**, the crate does not move**. Rank the situations shown in **Figure 8** according to the magnitude of the frictional force of the surface on the crate, **least to greatest**.

Figure 8



A) 3, 2, 1
B) 1, 2, 3
C) 2, 1, 3
D) 3, 1, 2
E) All tie

Ans:

$$Force\ of\ firction\ f = \mu F_N \Longrightarrow f \propto F_N$$

$$Case\ 1: F_N = mg$$

$$Case\ 2: F_N + 10 sin\theta = mg \Rightarrow F_N = (mg - 10 sin\theta)$$

$$case\ 3: F_N + 10 = mg \Longrightarrow F_N = mg - 10$$

Q19.

A coin placed 30.0 cm from the center of a rotating horizontal turntable slips when its speed reaches 50.0 cm/s. What is the coefficient of static friction between the coin and the turntable?

A) 0.085
B) 0.027
C) 0.045
D) 0.064
E) 0.019

Ans:

$$f - \frac{mv^2}{r} = 0\ when\ slips$$

$$\mu_s mg - \frac{mv^2}{r} = 0$$

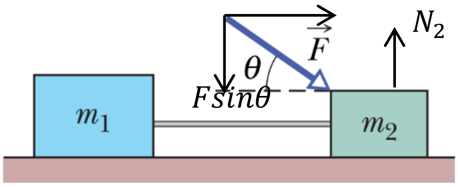
$$\mu_s = \frac{v^2}{rg} = \frac{(50 \times 10^{-2})^2}{(30 \times 10^{-2} \times 9.8)} = 0.085$$

Q20.

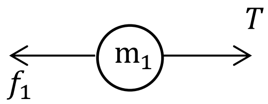
In **Figure 9**, block 1 of mass $m_1 = 2.0$ kg and block 2 of mass $m_2 = 1.0$ kg are connected by a string of negligible mass. Block 2 is pushed by a force of magnitude 20 N making an angle $\theta = 35°$ as shown. The coefficient of kinetic friction between each block and the horizontal surface is 0.20. What is the tension in the string?

A) 9.4 N
B) 6.2 N
C) 2.5 N
D) 7.1 N
E) 4.7 N

Figure 9



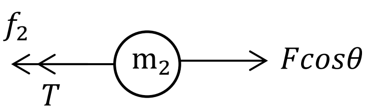
Ans:



$$T - f_1 = m_1 a$$

$$T - \mu_k m_1 g = m_1 a$$

$$a = \frac{T - 0.2 \times 2 \times 9.8}{2} = \frac{T}{2} - 1.96$$



$$Fcos\theta - f_2 - T = m_2 a$$

$$20cos35° - \mu_k F_{N2} - T = m_2 a$$

$$20cos35° - 0.2(m_2 g + Fsin35°) = m_2 a + T$$

$$1 \times \left(\frac{T}{2} - 1.98\right) + T = 20cos35° - 0.2(1 \times 9.8 + 20sin35°)$$

$$T = 9.4\ N$$