Q1.
An object moves in a circle at constant speed. The work done by the centripetal force is zero because:

A) the centripetal force is perpendicular to the velocity.
B) the change in kinetic energy of the object is not zero.
C) the centripetal force is parallel to the velocity.
D) the object is moving with constant velocity.
E) the centripetal force does not change velocity.

---

Q2.
A 4.0-kg cart starts up an incline with a speed of 3.0 m/s and comes to rest 2.0 m up the incline. The net work done on the cart is:

A) –18 J
B) +18 J
C) +12 J
D) –12 J
E) +1.0 J

---

Q3.
A block of mass 1.6 kg, resting on a horizontal frictionless surface, is attached to a horizontal spring fixed at one end. The spring, having a spring constant of 1.0 x $10^3$ N/m, is compressed to x = -2.0 cm (x = 0.0 is the equilibrium position) and the block is released from rest. The speed of the block as it passes through the position x = - 1.0 cm is:

A) 0.43 m/s
B) 0.91 m/s
C) 0.73 m/s
D) 0.22 m/s
E) 0.10 m/s

---

Q4.
A 3.0-kg mass has an initial velocity $\mathbf{v_o}$ = (6.0 **i** – 2.0 **j**) m/s. A single force **F** is applied for 5.0 s which changes its velocity to **v** = (8.0 **i** + 4.0 **j**) m/s. Find the average power delivered by the force in this interval.

A) 12 W
B) 25 W
C) 9.8 W
D) 6.6 W
E) 28 W

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Q5.

A projectile of mass m = 0.200 kg is fired at an angle of 60.0 degrees above the horizontal with a speed of 20.0 m/s. Find the work done on the projectile by the gravitational force during its flight from its firing point to the highest point on its trajectory.

A) –30.0 J
B) 9.60 J
C) –12.0 J
D) 40.0 J
E) –20.0 J

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Q6.
A 0.500-kg block is pushed against a horizontal spring fixed at one end (the block is NOT attached to the spring), compressing the spring 10.0 cm. The spring has a spring constant of $1.00 \times 10^2$ N/m. The block lies on a horizontal floor having a coefficient of kinetic friction $\mu_k$ = 0.200. Find the total distance traveled by the block after being released from rest.

A) 51.0 cm
B) 20.0 cm
C) 10.0 cm
D) 6.00 cm
E) 80.0 cm

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Q7.
A simple pendulum consists of a 2.00 kg mass attached to a 1.00 m long light string. It is given an initial speed of 0.500 m/s at A where the pendulum makes an angle θ with the vertical as shown in Fig.1. If its speed at the lowest point B is 1.70 m/s, find the value of the angle θ.

A) 30.1 degrees
B) 45.2 degrees
C) 20.7 degrees
D) 15.9 degrees
E) 10.7 degrees

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Q8.
A ball of mass m, attached at one end of a massless string of length L, rotates in a vertical circle fast enough to prevent the string from going loose at the top of the circle. Neglecting air resistance, during this motion, which ONE of the following statements is **WRONG:**

A) Change in mechanical energy is not zero.
B) The speed of the ball at the bottom of the circle is maximum.
C) The work done by the tension is zero.
D) Kinetic energy is not conserved.
E) Gravitational potential energy is not conserved.

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Q9.

Sphere A has mass m and is moving with velocity **v**. It makes a head-on elastic collision with a stationary sphere B of mass 2m. After the collision their speeds $v_A$ and $v_B$ are, respectively:

A) −v/3, 2v/3
B) 0, v/2
C) −v, v
D) −2v/3, v/3
E) v, -v

---

Q10.
A 3.0-kg and a 2.0-kg carts approach each other on a horizontal air track. They collide and stick together. After the collision their total kinetic energy is 0.40 x$10^2$ J. The initial speed of their center of mass was:

A) 4.0 m/s
B) 2.8 m/s
C) 0.0 m/s
D) 5.2 m/s
E) 6.3 m/s

---

Q11.
A projectile has a range R. At its highest point the projectile explodes into two equal parts. One part falls vertically down. How far from the **firing point** will the other part land?

A) 3R/2
B) R
C) 2R
D) R/2
E) 5R/2

---

Q12.
A 1.0-kg ball moving with a speed of 2.0 m/s perpendicular to a wall rebounds from the wall (opposite to its original direction) with a speed of 2.0 m/s .The change in the momentum of the ball is:

A) 4.0 N · s away from the wall
B) 1.5 N · s away from the wall
C) 2.5 N · s towards the wall
D) 0.0 N · s
E) 4.0 N · s towards the wall

---

Q13.
An object whose moment of inertia is 4.0 kg.m$^2$ experiences the net torque shown in Fig.2. What is the angular speed of the object at t = 3.0 s if it starts from rest?

A) 0.75 rad/s

B) 0.57 rad/s
C) 0.15 rad/s
D) 0.05 rad/s
E) 0.95 rad/s

---

Q14.
A uniform rod of length L = 10.0 m and mass M = 2.00 kg is pivoted about its center of mass O. Two forces of 10.0 and 3.00 N are applied to the rod, as shown in Fig.3. The magnitude of the angular acceleration of the rod about O is

A) 1.02 rad/$s^2$
B) 1.53 rad/$s^2$
C) 2.29 rad/$s^2$
D) 4.29 rad/$s^2$
E) 3.23 rad/$s^2$

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Q15.
A horizontal disk with a radius of 0.10 m rotates about a vertical axis through its center. The disk starts from rest at t = 0.0 s and has a constant angular acceleration of 2.1 rad/$s^2$. At what value of t will the radial and tangential components of the linear acceleration of a point on the rim of the disk be equal in magnitude?

A) 0.69 s
B) 0.33 s
C) 0.99 s
D) 0.29 s
E) 0.47 s

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Q16.
The average power needed to spin ( rotate about its axis) a uniform, solid disk of mass 5.0 kg and radius 0.50 m from rest to a final angular velocity $\omega_f$ in 3.0 s is 2.6 W. The final angular speed is:

A) 5.0 rad/s
B) 7.0 rad/s
C) 3.0 rad/s
D) 9.0 rad/s
E) 2.0 rad/s

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Q17.
A sphere of mass 1.40 x$10^2$ kg rolls on a horizontal floor so that its center of mass has a speed of 0.150 m/s. How much work must be done on the sphere to stop it?

A) – 2.21 J
B) + 2.21 J
C) – 5.35 J

D) + 4.55 J
E) – 1.15 J

---

Q18.
Two cylinders made of the same material roll down a plane inclined at an angle θ with the horizontal. Each travels the same distance. The radius of cylinder B is twice the radius of cylinder A. If they start from rest at the same height, in what order do they reach the bottom.

A) They both reach the bottom at the same time, because each has the same linear acceleration.
B) A reaches the bottom first because it has a greater acceleration.
C) A reaches the bottom first because it has a smaller moment of inertia.
D) B reaches the bottom first because it experiences a larger torque.
E) B reaches the bottom first because it travels a larger distance in one rotation.

---

Q19.
A 2.0-kg particle has a velocity **v** = (2.0 **i** + 4.0 **j**) m/s at the point (2.0, -2.0) m. Find its angular momentum relative to the point (- 2.0, - 2.0) m at this moment.

A) + 32 **k**
B) – 32 **k**
C) + 16 **j**
D) – 16 **j**
E) + 24 **i**

---

Q20.
A student holding two weights close to his chest is sitting on a frictionless chair; the student and chair are rotating with an angular speed of 10 rad/s. The moment of inertia of Student + Weights + Chair system about the axis of rotation is 20 kg.m$^2$. Now the student extends his arms horizontally to increase the moment of inertia by 10 %. Find the new angular speed of the system?

A) 9.1 rad/s
B) 7.0 rad/s
C) 5.3 rad/s
D) 3.5 rad/s
E) 6.4 rad/s

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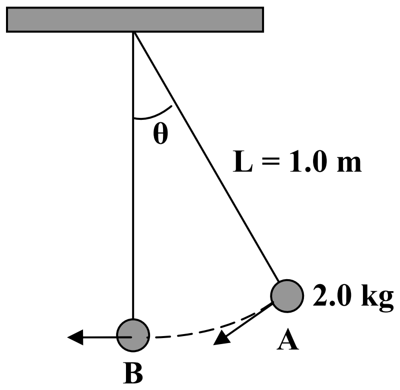


Fig.1

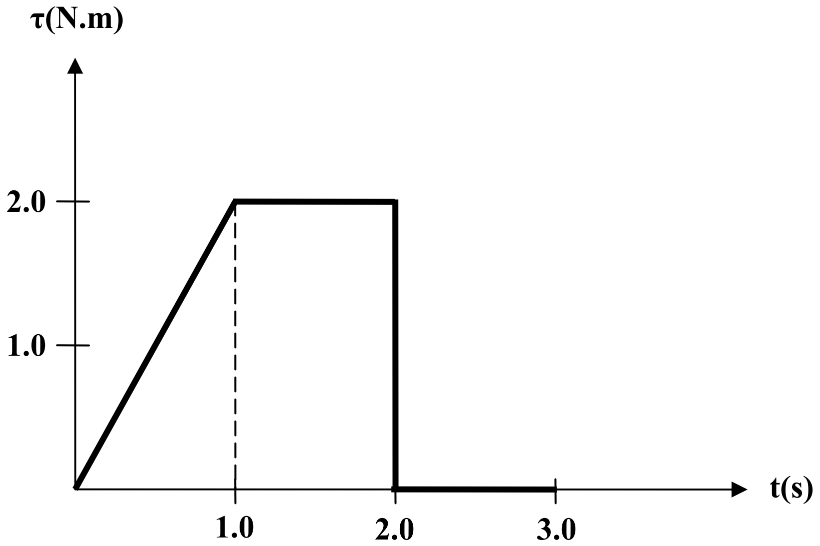


Fig.2

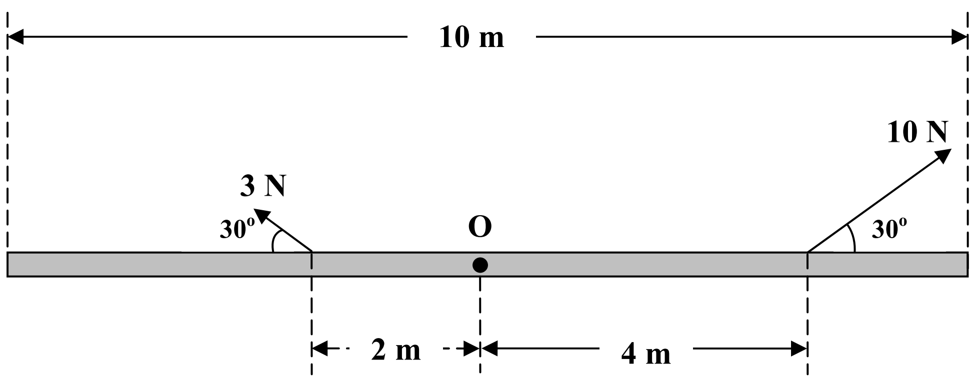


Fig.3

$$\vec{r}-\vec{r}_o=\vec{v}_o t+\frac{1}{2}\vec{a}t^2$$
$$\vec{v}=\vec{v}_o+\vec{a}t$$
$$v^2=v_o^2+2a(x-x_o)$$
$$x-x_o=\frac{1}{2}(v+v_o)t$$

$$\sum\vec{F}=m\vec{a}=\frac{d\vec{p}}{dt};\qquad \vec{p}=m\vec{v}$$
$$f_k=\mu_k N$$
$$f_s\le\mu_s N$$
$$W=\int\vec{F}\cdot d\vec{r}$$
$$W=\vec{F}\cdot\vec{d}\quad \text{if } \vec{F} \text{ is a constant}$$

$$\vec{A}\cdot\vec{B}=A\,B\,\cos\theta$$
$$|\vec{A}\times\vec{B}|=A\,B\,\sin\theta$$

$$W_{net}=\Delta K=\frac{1}{2}mv_f^2-\frac{1}{2}mv_i^2$$
$$P=\frac{dW}{dt}=\vec{F}\cdot\vec{v}$$
$$U_s=\frac{1}{2}kx^2,\qquad F_s=-kx$$
$$U_g=mgy$$
$$E_{mech}=K+U$$
$$\Delta U=-W\quad \text{for a conservative force}$$
$$\Delta K+\Delta U+\Delta E_{th}=W$$
$$\text{where}\quad \Delta E_{th}=f_k d$$

$$\vec{J}=\int\vec{F}\,dt=\vec{F}_{avg}\Delta t=\Delta\vec{p}$$
$$\vec{p}_{1i}+\vec{p}_{2i}=\vec{p}_{1f}+\vec{p}_{2f}$$
$$\sum\vec{F}_{ext}=M\vec{a}_{com}$$
$$\vec{r}_{com}=\frac{1}{M}\sum_{i=1}^{n}m_i\vec{r}_i=\frac{1}{M}\int\vec{r}\,dm$$
$$v_{1f}=\frac{m_1-m_2}{m_1+m_2}v_{1i}+\frac{2m_2}{m_1+m_2}v_{2i}$$
$$v_{2f}=\frac{2m_1}{m_1+m_2}v_{1i}+\frac{m_2-m_1}{m_1+m_2}v_{2i}$$

$$\omega=\frac{d\theta}{dt};\quad \alpha=\frac{d\omega}{dt}$$
$$s=r\theta,\qquad v=r\omega$$
$$a_t=r\alpha;\quad a_r=\frac{v^2}{r}=r\omega^2$$
$$\vec{a}=\vec{a}_t+\vec{a}_r;\qquad a=\sqrt{a_t^2+a_r^2}$$

*If $\alpha$ is constant:*
$$\omega=\omega_o+\alpha t$$
$$\theta-\theta_o=\omega_o t+\frac{1}{2}\alpha t^2$$
$$\omega^2=\omega_o^2+2\alpha(\theta-\theta_o)$$

$$I=\sum_i m_i r_i^2=\int r^2\,dm$$
$$I_p=I_{com}+Mh^2$$
$$\vec{\tau}=\vec{r}\times\vec{F}$$
$$\tau=rF\sin\theta=r_\perp F=rF_t$$
$$W=\int\tau\,d\theta$$
$$=\tau\,\Delta\theta\quad \text{if } \tau \text{ is constant}$$
$$\vec{l}=\vec{r}\times\vec{p}=m\vec{r}\times\vec{v}$$
$$l=mr_\perp v=mrv_\perp$$

*For a solid rotating about a fixed axis:*

$$K_{rot}=\frac{1}{2}I\omega^2,\qquad L_z=I\omega$$
$$\Delta K=\frac{1}{2}I(\omega_f^2-\omega_i^2)=W$$
$$P=\frac{dW}{dt}=\tau\omega$$
$$\vec{\tau}=\frac{d\vec{l}}{dt}$$
$$\sum\vec{\tau}_{ext}=\frac{d\vec{L}}{dt}=I\vec{\alpha}$$

$$\int x^n dx=\frac{x^{n+1}}{n+1};\qquad \frac{d}{dt}(t^n)=n\,t^{n-1}$$

$$g=9.80\ m/s^2$$
$$I_{com}(cylinder, disk)=\tfrac{1}{2}MR^2$$
$$I_{com}(solid\ sphere)=\tfrac{2}{5}MR^2$$
$$I_{com}(thin\ rod)=\tfrac{1}{12}ML^2$$
$$I_{com}(ring,\ about\ central\ axis)=MR^2$$
$$I_{com}(ring,\ about\ diameter)=\tfrac{1}{2}MR^2$$