Q1.
A 5.0 kg object moving along the x-axis has a velocity of 5.0 m/s at x = 1.0 m. If the only force acting on this object is shown in **Figure 1**, what is the speed of the object at x = 6.0 m?

A) 8.1 m/s
B) 4.4 m/s
C) 3.5 m/s
D) 10 m/s
E) 12 m/s

Q2.
A man moves the 10-kg object shown in **Figure 2** in a vertical plane from position X to position Y along a circular track of radius R = 20 m. The work done by the force of gravity during this motion is

A) – 3920 J
B) + 3920 J
C) – 1260 J
D) + 1260 J
E) + 4240 J

Q3.
In **Figure 3**, a 2.0 kg object slides on a frictionless horizontal surface toward a spring. The speed of the object just before it hits the spring is 6.0 m/s and its speed when the spring is compressed 15 cm is 3.7 m/s. Find the spring constant of the spring.

A) 2.0×10^3 N/m
B) 1.0×10^3 N/m
C) 3.0×10^3 N/m
D) 4.0×10^3 N/m
E) 5.0×10^3 N/m

Q4.
Figure 4 shows two equal forces of magnitude F = 10 N acting on a box as the box slides to the right across a frictionless floor. The speed of the box at a certain instant is 4.0 m/s. Calculate the net power due to these two forces at that instant?

A) 20 W
B) 15 W
C) 24 W
D) 10 W
E) 30 W

Q5.
A 3.0 kg block starts from rest on a rough inclined plane that makes an angle of 35^o with the horizontal as shown in **Figure 5**. As the block moves 2.0 m down the incline, its speed is 4.0 m/s. Find the value of the coefficient of kinetic friction between the block and the incline.

A) 0.2
B) 0.3

C) 0.1
D) 0.8
E) 0.4

Q6.
A particle moves from point A to point B under the influence of only two forces. One force is conservative and does 50 J of work. The other is non-conservative and does 20 J of work. What is the change in kinetic energy of the particle?

A) 70 J
B) 30 J
C) – 70 J
D) – 30 J
E) Zero

Q7.
A 2.0 kg object is thrown vertically upward with an initial speed of 30 m/s. After moving a vertical distance of 25 m, its speed is 5.0 m/s. How much work is done by the air resistance on the object during this upward motion?

A) – 385 J
B) – 424 J
C) – 125 J
D) – 240 J
E) – 500 J

Q8.
A 5-kg object is subjected to a force $\vec{F}$. The variation of the force $\vec{F}$ as a function of time t is shown in **Figure 6**. Calculate the change in the velocity of the object during the time interval the force is applied.

A) 0.8 m/s
B) 0.2 m/s
C) 4.0 m/s
D) 3.2 m/s
E) 2.1 m/s

Q9.
A 5.0-kg object moving with a speed of 5.0 m/s in the positive x-direction collides and sticks to a 1.0-kg object originally moving with a speed of 4.0 m/s in the negative x-direction. What is the final speed of the two masses?

A) 3.5 m/s
B) 1.0 m/s
C) 9.0 m/s
D) 4.8 m/s
E) 1.5 m/s

Q10.

A 2.00-kg particle has a velocity of 4.00 m/s in the positive x direction and a 3.00-kg particle has a velocity of 5.00 m/s in the positive y direction. What is the speed of their center of mass?

A) 3.40 m/s
B) 23.0 m/s
C) 17.0 m/s
D) 9.00 m/s
E) 4.60 m/s

Q11.
Three particles are placed in the xy plane. A 5-gram particle is located at (3, 4) m, and a 7-gram particle is located at (−1,−6) m. Where a 2-gram particle must be placed so that the center of mass of this three-particle system is located at the origin?

A) (−4 , 11) m
B) (2 , −2) m
C) (4 , 10) m
D) (9 , 16) m
E) (-2 , 10) m

Q12.
The four particles shown in **Figure 7** are connected by rigid rods of negligible mass. Calculate the moment of inertia of this system about the x-axis.

A) 3 $kg.m^2$
B) 6 $kg.m^2$
C) 2 $kg.m^2$
D) 19 $kg.m^2$
E) 5 $kg.m^2$

Q13.
An average torque of 1.0 N·m about the fixed axis of rotation of a pulley increases its angular speed from 5.0 rad/s to ω_f in 3.0 s. The moment of inertia of the pulley about its axis of rotation is 0.2 $kg.m^2$. Find ω_f.

A) 20 rad/s
B) 10 rad/s
C) 15 rad/s
D) 12 rad/s
E) 40 rad/s

Q14.
Assume that a disk starts from rest and rotates with an angular acceleration of 4.00 rad/s^2. The time it takes to rotate through the first **five** revolutions is:

A) 3.96 s
B) 30.0 s
C) 1.58 s
D) 0.80 s

E) 20.0 s

Q15.
Three point masses M, 2M and 3M, are attached to a rod of mass M and length L as shown in **Figure 8**. Take M = 1.00 kg and L = 1.00 m. The rotational kinetic energy of the system when rotating about the vertical z-axis through the mass 3M with a speed of 4.00 rad/s is:

A) 14.7 J
B) 6.00 J
C) 38.7 J
D) 56.0 J
E) 24.0 J

Q16.
A solid cylinder rolls without sliding along the floor. The ratio of its translational kinetic energy to its rotational kinetic energy (about an axis through its center of mass and along its length) is:

A) 2
B) 1
C) 3
D) 1/4
E) 1/3

Q17.
When we apply the energy conservation principle to a cylinder rolling down an incline without sliding, the work done by friction is zero because:

A) the linear velocity of the point of contact between the cylinder and the plane is zero
B) the angular velocity of the center of mass about the point of contact is zero
C) the coefficient of kinetic friction is zero
D) there is no friction present
E) the coefficients of static and kinetic friction are equal

Q18.
Two objects moving in the xy plane are shown at a certain instant in **Figure 9**. The magnitude of the total angular momentum (about the origin O) at this instant is:

A) 30 $kg \cdot m^2/s$
B) 6 $kg \cdot m^2/s$
C) 12 $kg \cdot m^2/s$
D) 78 $kg \cdot m^2/s$
E) Zero

Q19.
A 3.0-kg block is located on the x-axis 2.0 m from the origin and is acted upon by a force $\vec{F} = 8.0\ \hat{i}$ N. Find the net torque acting on the block relative to the origin.

A) Zero

B) $-12\,k$ N.m
C) $-16\,k$ N.m
D) $24\,k$ N.m
E) $16\,k$ N.m

Q20.
Figure 10 is an overhead view of a uniform thin rod (of length 1 m and mass 2 kg) rotating horizontally at 18 rad/s counter-clockwise about a vertical axis through its center. A particle of mass 0.2 kg traveling horizontally at 30 m/s hits the rod and stick to it at a distance d from the axis of rotation. At the time of collision with the rod, the particle was traveling perpendicular to the rod. Right after the collision, the (rod + particle) system comes to rest. Find the value of d.

A) 0.5 m
B) 0.4 m
C) 0.3 m
D) 0.2 m
E) Zero

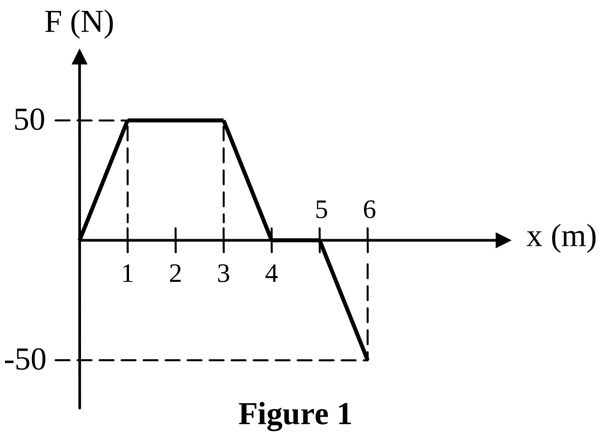

Figure 1

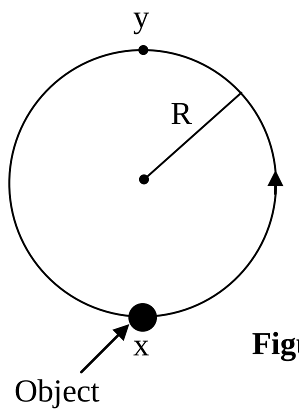

Figure 2

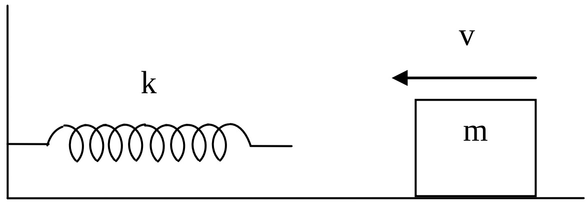

Figure 3

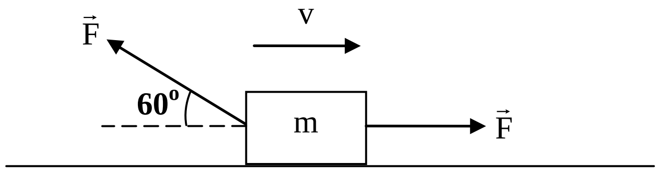

Figure 4

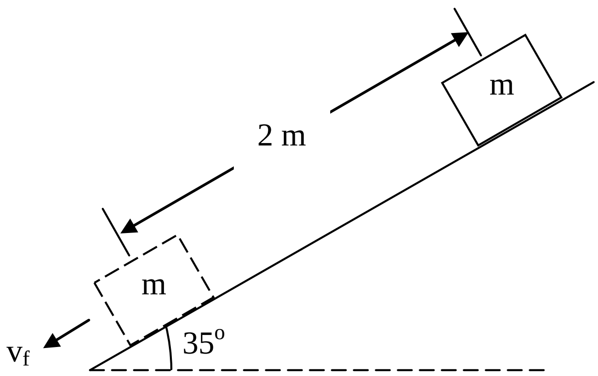

Figure 5

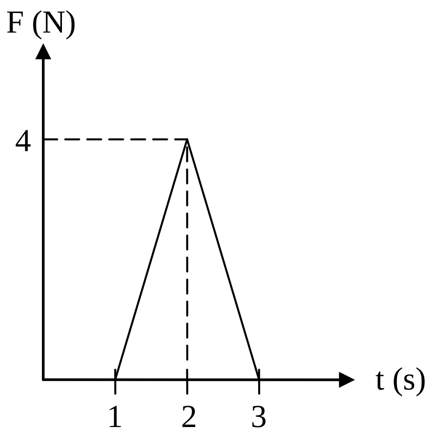

Figure 6

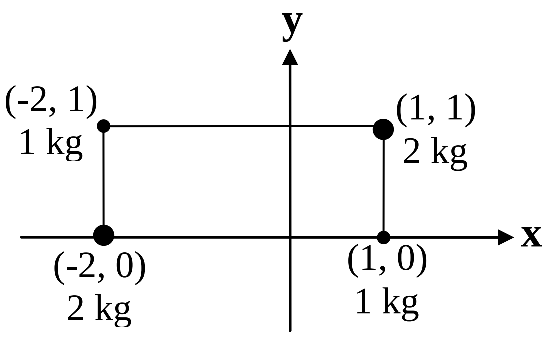

Figure 7

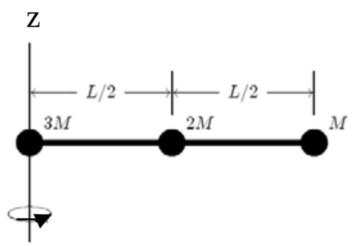

Figure 8

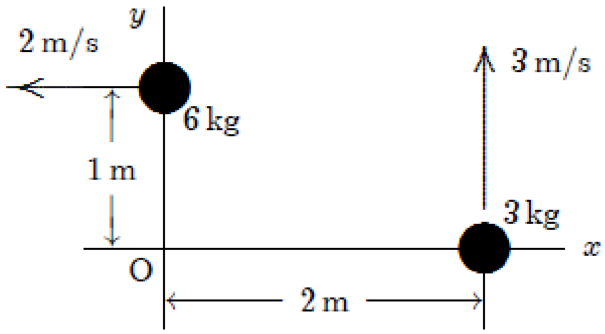

Figure 9

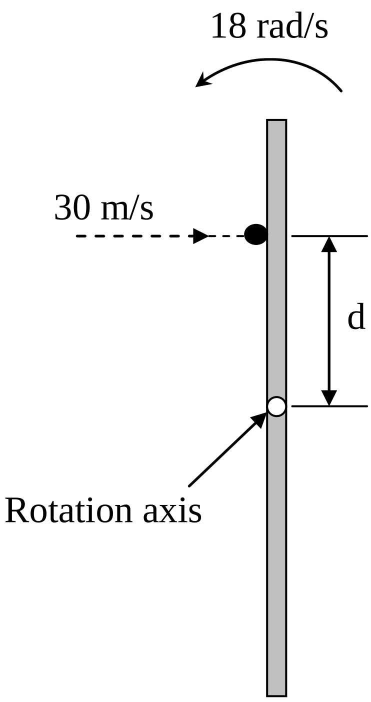

Figure 10

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

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

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

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

$$\Delta K+\Delta U+\Delta E_{th}=W$$
$$where \quad \Delta E_{th}=f_k d$$

$$\vec{J}=\int\vec{F}\,dt=\vec{F}_{avg}\Delta t=\Delta\vec{p}$$
$$\vec{p}_{1i}+\vec{p}_{2i}=\vec{p}_{1f}+\vec{p}_{2f}$$

$$\sum\vec{F}_{ext}=M\vec{a}_{com}$$
$$\vec{r}_{com}=\frac{1}{M}\sum_{i=1}^{n}m_i\vec{r}_i=\frac{1}{M}\int\vec{r}\,dm$$

$$v_{1f}=\frac{m_1-m_2}{m_1+m_2}v_{1i}+\frac{2m_2}{m_1+m_2}v_{2i}$$
$$v_{2f}=\frac{2m_1}{m_1+m_2}v_{1i}+\frac{m_2-m_1}{m_1+m_2}v_{2i}$$

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

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

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

For a solid rotating about a fixed axis:

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

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

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