Q1.
A stone is thrown **upward** from the top of a building. It takes a time t_o for the stone to reach the ground. Which one of the plots shown in Figure 1 best represents the change of the kinetic energy of the stone with time?

A) (a)
B) (b)
C) (c)
D) (d)
E) None of the plots

Q2.
A body of mass M = 2.00 kg, tied to a string, rotates in a vertical circle of radius R = 1.00 m. Find the work done by the force of gravity on the body during one full revolution.

A) zero
B) 39.2 J
C) 19.6 J
D) 61.6 J
E) 123 J

Q3.
Two constant forces $\vec{F}_1 = (-5.0\,\hat{i} + 3.0\,\hat{j})$ N and $\vec{F}_2 = (3.0\,\hat{i} - 3.0\,\hat{j})$ N act on a box as it slides across a frictionless (xy)-horizontal floor. What is the power due to the two forces at the instant when the velocity of the box is 2.3 m/s along the positive x-axis?

A) – 4.6 W
B) zero
C) – 18 W
D) 3.5 W
E) 1.4 W

Q4.
Figure 2 shows an object of mass m = 1.00 kg starting from rest. It first slides a distance 45.0 cm down a frictionless inclined surface and then slides across a rough horizontal surface whose coefficient of kinetic friction is 0.150. What is the maximum distance d travelled by the object across the horizontal surface?

A) 103 cm
B) 47.0 cm
C) 245 cm
D) 9.70 cm
E) 877 cm

Q5.
Figure 3 shows three identical blocks that are moving on three identical rough surfaces having the same coefficient of kinetic friction. They all move the same distance parallel to the surface. Rank the 3 situations according to the magnitude of the work done by the force of friction, greatest first.

A) a then b and c tie
B) a then b then c
C) b then a, then c
D) c then b, then a
E) not enough information to decide

Q6.
A block of mass 0.75 kg is free to move on a horizontal surface where $\mu_k = 0.25$. The block is placed against a spring with a spring constant k = 83 N/m. The spring is compressed 0.10 m and then the block is released from rest. Find the speed of the block just as it leaves the spring.

A) 0.79 m/s
B) 1.5 m/s
C) 1.2 m/s
D) 0.87 m/s
E) zero

Q7.
A block of mass 2.00 kg is released from rest and slides down a rough track of radius R = 1.00 m as shown in Figure 4. If the speed of the block at the bottom of the track is 4.00 m/s, what is the work done by the frictional force acting on the block?

A) – 3.60 J
B) – 19.1 J
C) – 1.50 J
D) – 21.5 J
E) zero

Q8.
Consider the system of particles shown in Figure 5. Where should a 4th particle of mass 4.0 kg be placed so that the center of mass of the four particles system is located at (4 m, 4 m)?

A) (5.5 m, 8.5 m)
B) (5.5 m, 3.5 m)
C) (2.1 m, 8.5 m)
D) (2.1 m, 4.0 m)
E) (2.1 m, 6.5 m)

Q9.
Two boys, with masses of 40 kg and 60 kg, respectively, stand on a horizontal frictionless surface holding the ends of a 10 m long massless rod. The boys pull themselves toward each other along the rod. When they meet, what distance will the 60 kg boy have covered?

A) 4.0 m
B) 5.0 m
C) 6.0 m
D) 2.0 m
E) 10 m

Q10.
A 0.55 kg ball falls directly down onto concrete hitting it with a speed of 4.0 m/s and rebouncing directly upward with the same speed of 4.0 m/s. What is the impulse on the ball? ($\hat{j}$ is the unit vector in the upward positive y-direction)

A) (+4.4 N.s) $\hat{j}$
B) (– 4.4 N.s) $\hat{j}$
C) (+8.0 N.s) $\hat{j}$
D) (–8.0 N.s) $\hat{j}$
E) zero

Q11.
A collision between two objects is completely inelastic. Which one of the following statements concerning this collision is **TRUE**?

A) The total kinetic energy of the objects after the collision is less than it was before collision
B) The vector sum of the velocities of the two objects must be zero after the collision
C) The total momentum of the two objects after the collision is less than it was before the collision
D) The objects bounce away from each other after the collision
E) The total kinetic energy of the objects must be zero after collision

Q12.
A turntable is initially rotating at 33 rev/min. When the power to the turntable is switched off, the turntable slows down at a constant rate of 0.20 rad/s^2. How many revolutions will the turntable make before coming to a full stop?

A) 4.7
B) 2.1
C) 1.5
D) 3.1
E) 6.2

Q13.
Figure 6 shows the time variation of a torque applied tangentially to the edge of a 10.0 kg uniform disk rotating about its central axis. If the initial angular velocity of the disk is −50 rad/s, what is its angular velocity after 0.500 seconds? The disk has a radius of 10 cm.

A) 20 rad/s
B) −20 rad/s
C) 70 rad/s
D) zero
E) −70 rad/s

Q14.
A 32.0 kg thin hoop (ring) with radius 1.20 m, is rotating at 280 rev/min about its axis. What is the required average power of the net force that brings the hoop to a full stop in 15.0 s?

A) 1.32×10^3 W
B) 2.56×10^3 W
C) 1.09×10^3 W
D) 4.35×10^3 W
E) 10.1×10^3 W

Q15.
Four forces of the same magnitude act on a square frame that can rotate about the middle point P as shown in Figure 7. Rank the forces acting on it according to the magnitude of the torque they produce about point P, greatest first. (assume all forces in the plane of the square)

A) F_4, F_3, F_1, F_2
B) F_3, F_4, F_1, F_2
C) F_4, F_3, F_2, F_1
D) F_1, F_2, F_3, F_4
E) F_2, F_3, F_1, F_4

Q16.
A wheel of radius R = 0.500 m rolls smoothly (without sliding) on a horizontal surface. Starting from rest, the wheel moves with a constant angular acceleration of 6.00 rad/s^2. The distance traveled by the center of the wheel between t = 0 and t = 3.00 s is:

A) 13.5 m
B) 27.0 m
C) zero
D) 18.0 m
E) 35.0 m

Q17.
A solid cylinder of mass M = 1.0 kg and radius R = 10 cm rolls smoothly (without sliding) down a 30^0 rough incline. Find the force of static friction acting along the incline at the point of contact between the incline and the cylinder.

A) 1.6 N
B) 0.80 N
C) 3.2 N
D) 4.5 N
E) 9.8 N

Q18.
A single force acts on a particle situated on the positive x axis. The torque about the origin is in the negative z direction. The force might be:

A) in the negative y direction
B) in the positive y direction
C) in the positive x direction

D) in the negative x direction
E) in the positive z direction

Q19.
A 6.00 kg particle moves to the right at 4.00 m/s as shown in Figure 8. Its angular momentum about the point O is:

A) 144 kg m^2/s into the page
B) zero
C) 144 kg m^2/s out of the page
D) 249 kg m^2/s into the page
E) 249 kg m^2/s out of the page

Q20.
A man of mass 80 kg, holding a stone of mass 2.0 kg, stands at the rim of a turntable of radius 4.0 m and mounted on a frictionless shaft through its center. The rotational inertia of the turntable is 2.0×10^3 kg.m^2. The whole system is initially at rest. Now, the man throws the stone tangentially out with a speed of 2.0 m/s relative to the ground. Calculate the angular speed of the man-turntable system. You may consider the man as a point mass.

A) 4.9×10^{-3} rad/s
B) 2.8×10^{-3} rad/s
C) 3.5×10^{-3} rad/s
D) 7.0×10^{-3} rad/s
E) zero

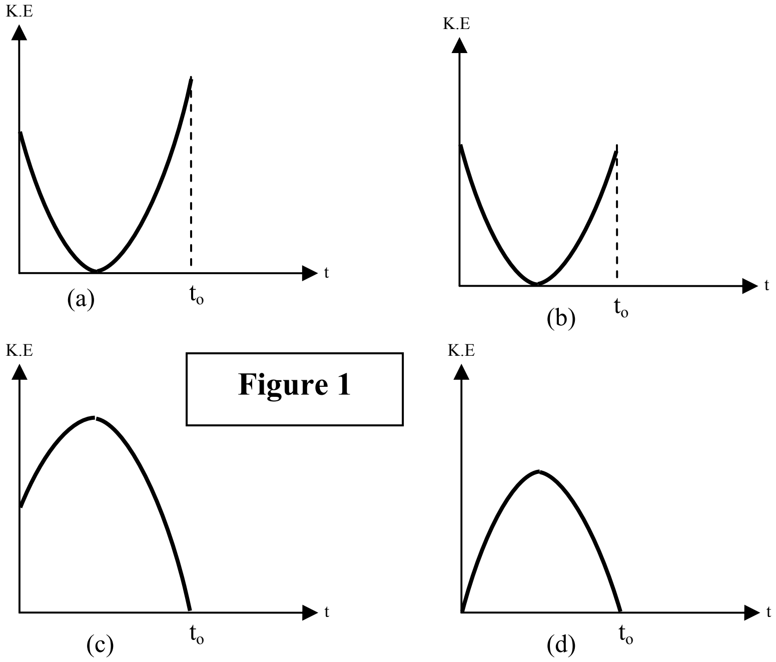

Figure 1

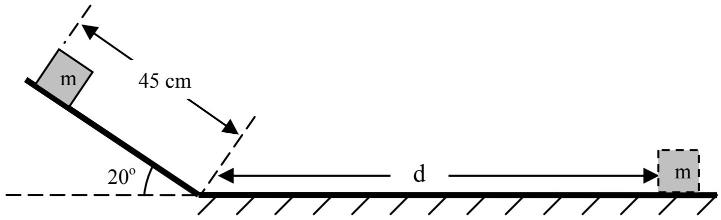

Figure 2

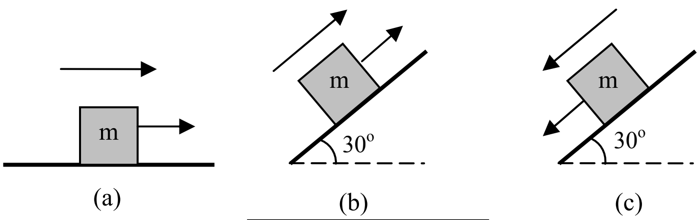

Figure 3

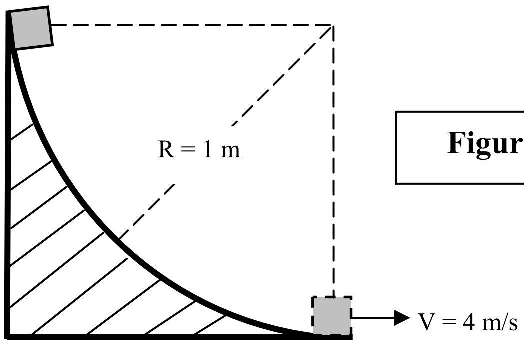

Figure 4

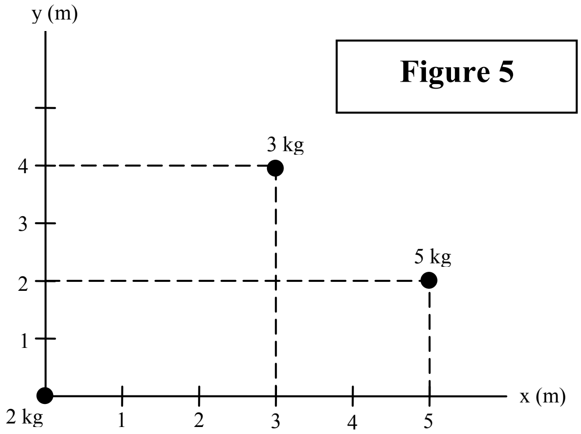

Figure 5

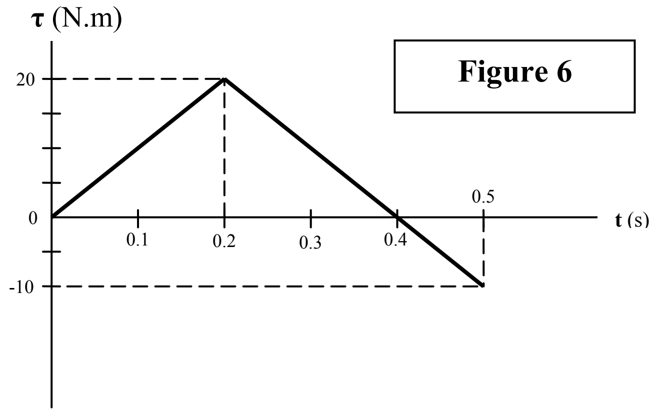

Figure 6

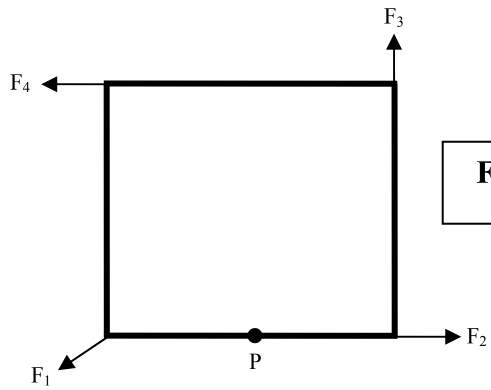

Figure 7

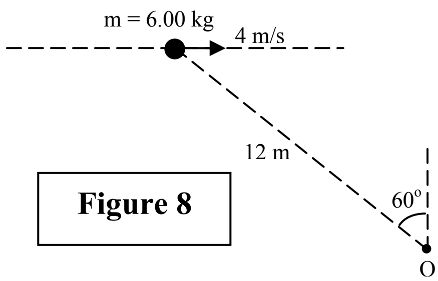

Figure 8

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

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

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

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

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

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

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

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

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

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

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

For a solid rotating about a fixed axis:

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

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

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