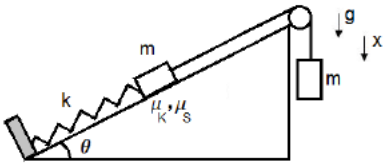
		Surname		Type
Group Number		Name		A
List Number		e-mail		
Student ID		Signature		

ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

Questions 1-4

Two blocks of equal mass m are connected to each other by a string. One block is attached to an outstretched (at its natural length) spring on a surface with friction while the other is hanging from a frictionless pulley of negligible mass as shown in the figure. The system is released and the masses come to rest after moving a distance L. Acceleration due to gravity g=10 m/s^2, m=5 kg, spring constant k=10 N/m, the coefficients of static and kinetic friction between the inclined plane and the block on it are $\mu_S = 0.3$ and $\mu_K = 0.1$ respectively, $\sin\theta = 0.6$, $\cos\theta = 0.8$.



1. How much work does the net force do until the blocks stop?
(a) 152 J (b) 160 J (c) 64 J (d) 220 J (e) 0 J

2. By how much are the blocks displaced?
(a) 4.4 m (b) 2.8 m (c) 3.2 m (d) 1.6 m (e) 4 m

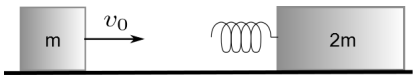
3. What is the displacement of the blocks when their speed is maximum?
(a) 2 m (b) 1.6 m (c) 3.2 m (d) 5.6 m (e) 2.2 m

4. What is the instantaneous power delivered to the system by gravity when the speed of the blocks is 1.4 m/s?
(a) 56 W (b) 14 W (c) 28 W (d) 42 W (e) 70 W

5. Suppose you throw a 0.5 kg ball with an initial speed of 10.0 m/s at an angle of 30° above the horizontal from a building 40.0 m high. What will be the speed of the ball when it hits the ground? Take $g = 10\,\mathrm{m/s^2}$.
(a) 40 m/s (b) 30 m/s (c) 50 m/s (d) 20 m/s (e) 15 m/s

Questions 6-9

There are two blocks of mass m and $2m$ on a frictionless air rail. The former is moving with velocity v_0 toward the other. The latter is at rest and attached to a spring with force constant K. The moving block comes into contact with the spring and compresses it and eventually forces the second one to move. See figure.



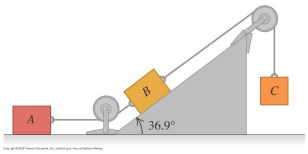
6. What is the minimum kinetic energy of the system?
(a) mv_0^2 (b) $mv_0^2/6$ (c) $mv_0^2/2$ (d) 0 (e) $2mv_0^2$

7. What is the maximum compression x_{max} of the spring?
(a) $\sqrt{\frac{m}{3K}}v_0$ (b) 0 (c) $\sqrt{\frac{4m}{3K}}v_0$ (d) $\sqrt{\frac{2m}{K}}v_0$ (e) $\sqrt{\frac{2m}{3K}}v_0$

8. What is the final kinetic energy of the system?
(a) $3mv_0^2/2$ (b) mv_0^2 (c) $mv_0^2/2$ (d) 0 (e) v_0^2

9. What is the final velocity of the block of mass m?
(a) $-v_0$ (b) 0 (c) v_0 (d) $-v_0/3$ (e) $-mv_0/3$

10. Three blocks are connected as shown. The ropes and pulleys are of negligible mass. When released, block C moves downward, block B moves up the ramp, and block A moves to the right. After each block has moved a distance d, the force of gravity has done
(a) zero work on A, negative work on B, and positive work on C. (b) zero work on A, positive work on B, and negative work on C. (c) none of these. (d) positive work on A, B, and C. (e) negative work on A, B and C.



Questions 11-13

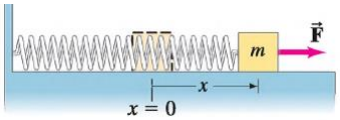
The position vector of an object with 2kg mass is given as $\vec{r} = t\hat{i} + t^3\hat{j}$

11. Find the force acting on the object?
(a) $24\hat{j}$N (b) cannot find. (c) $6\hat{j}$N (d) $12t\hat{j}$N (e) $12\hat{j}$N

12. Find the work done by the force in first 2 seconds.
(a) 144 J. (b) cannot find. (c) 100 J (d) 76.8 J (e) 77 J

13. Find the power at t = 1s.
(a) 0 (b) 72 Watt (c) 144 Watt (d) 9 Watt (e) 36 Watt

14. A mass m is attached to a spring which is held stretched a distance x by a force F, and then released. The spring compresses, pulling the mass. Assuming there is no friction, determine the speed of the mass m when the spring returns to half its original extensions.



(a) $\sqrt{\frac{3Fx}{4m}}$ (b) $\sqrt{\frac{Fx}{m}}$ (c) $\sqrt{\frac{Fx}{4m}}$ (d) $\sqrt{\frac{Fx}{2m}}$ (e) $\sqrt{\frac{2Fx}{m}}$

15. A bicyclist coasts down a slope with an angle α, for which $\sin(\alpha) = 0.1$, at a steady speed of 5 m/s. Assuming a total mass of 70 kg (bicycle plus rider), what must the cyclist's power output be to pedal up the same slope at the same speed? Take $g = 10\,\mathrm{m/s^2}$.

(a) 3500 W (b) 700 W (c) 1200 W (d) 350 W (e) 1400 W

16. Is it possible to have a force which gives zero impulse over a nonzero time interval even though the force is not zero at least a part of that time interval? How?

(a) No, constant force. (b) Yes, non-constant force. (c) Not possible. (d) No, non-constant force. (e) Yes, constant force.

Questions 17-19

Suppose that two bodies, A ($m_A = 1.0$ kg) and B (m_B=2.0 kg), collide. The velocities before the collision are $\vec{v_A} = 1.5\hat{i} + 3\hat{j}$ m/s and $\vec{v_B} = -0.5\hat{i} + 0.5\hat{j}$ m/s. After the collision the velocity of block A is $\vec{v_A'} = -0.5\hat{i} + 2\hat{j}$ m/s .

17. What is the x component of the velocity of B after collision in m/s?

(a) 2 (b) 3 (c) 0.5 (d) 1.5 (e) 1

18. What is the velocity of the center of mass of the system before collision in m/s?

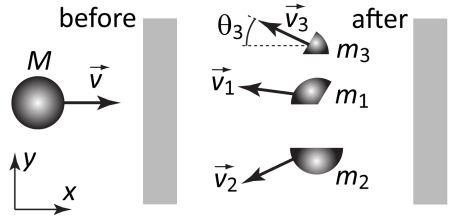
(a) $-\frac{1}{3}\hat{i} + \frac{1}{6}\hat{j}$ (b) $\frac{1}{2}\hat{i} + \hat{j}$ (c) $\frac{1}{6}\hat{i} + \frac{4}{3}\hat{j}$ (d) $\frac{5}{6}\hat{i} + \frac{5}{6}\hat{j}$ (e) $\frac{1}{6}\hat{i} + \frac{7}{6}\hat{j}$

19. What is the position vector of the center of mass of the system before collision at $t = 2.0$ s in meter? Initial positions of the masses are given as $\vec{r_A}(t{=}0) = 0$ and $\vec{r_B}(t{=}0) = 0.5\hat{i} + 1\hat{j}$ for m_A and m_B, respectively.

(a) $-\frac{1}{6}\hat{i} + \frac{4}{3}\hat{j}$ (b) $\frac{1}{3}\hat{i} + \frac{7}{3}\hat{j}$ (c) $6\hat{i} + 3\hat{j}$ (d) $\frac{2}{3}\hat{i} + \frac{10}{3}\hat{j}$ (e) $-\frac{1}{3}\hat{i} + \frac{8}{3}\hat{j}$

Questions 20-21

A clay ball with mass $M = 6\sqrt{2}$ kg is thrown directly against a perpendicular wall at a velocity of $\vec{v} = (6/\sqrt{2})\hat{i}$ m/s along the positive x-axis and shatters into three pieces, which all fly backward, as shown in the figure. The wall exerts a normal force of 1930 N on the ball for 0.1 s. One piece of mass $m_1 = 2\sqrt{2}$ kg travels backward with velocity $\vec{v}_1 = \left[(-40/\sqrt{2})\hat{i} + (10/\sqrt{2})\hat{j}\right]$ m/s. A second piece of mass $m_2 = 3\sqrt{2}$ kg travels backward at velocity $\vec{v}_2 = \left[(-25/\sqrt{2})\hat{i} - (6/\sqrt{2})\hat{j}\right]$ m/s.



20. What is the speed v_3 of the third piece with mass m_3 after the collision?

(a) 2 m/s (b) $2\sqrt{2}$ m/s (c) $\sqrt{2}$ m/s (d) $4\sqrt{2}$ m/s (e) 1 m/s

21. What is the angle θ_3 between the direction of motion of the third piece with mass m_3 and the horizontal after the collision? Take positive angles for directions above the horizontal and negative angles for directions below the horizontal.

(a) 30° (b) 45° (c) −30° (d) −45° (e) −60°

22. The angular velocity of a wheel is rotating on a horizontal axle point west. In what direction is the linear velocity of point on the top of the wheel? If the angular acceleration point east, describe the tangential linear acceleration of this point at the top of the wheel. Is the angular speed increasing or decreasing?

(a) East, West, Decreasing (b) South, North, Decreasing (c) West, North, Increasing (d) West, East, Increasing (e) North, South, Decreasing

Questions 23-25

Two masses are attached to opposite ends of a thin L-long horizontal rod. The system is rotating at angular speed ω about a vertical axle at the center of the rod. If we increase the angular speed two times larger than the current system:

23. What will be the fraction of kinetic energy between two systems?

(a) 1 (b) 1/4 (c) 1/2 (d) 2 (e) 4

If we shift the vertical axle to the middle between m_A and the center of the rod:

24. What will be the mass ratio $(m_A/m_B)$to get an equal net force between two masses?

(a) 1/3 (b) 3/2 (c) 1 (d) 3 (e) 2/3

Now assuming that axle passes through the center-of-mass (CM) of the system:

25. Determine the kinetic energy with m_A=4.0 kg and m_B=3.0 kg, the length of the rod 14 cm and angular speed $\omega = 2$ rad/s.

(a) 0.48 J (b) 0.96 J (c) 1.92 J (d) 0.16 J (e) 0.32