		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 1-5

A small piece of packing material with m = 3 kg is dropped from a height of 2 m above the ground. Until it reaches terminal speed, the magnitude of its acceleration is given by $a = g - bV$. After falling 0.5 m the material reaches its terminal speed, and then takes 3 s more to reach the ground. ($g = 10\text{m/s}^2$)

1. What is the terminal speed of the material?
(a) 0.3 m/s (b) 0.2 m/s (c) 0.5 m/s (d) 1 m/s (e) 0.4 m/s

2. What is the value of the constant b?
(a) 40 s^{-1} (b) 4 s^{-1} (c) 5 s^{-1} (d) 20 s^{-1} (e) 10 s^{-1}

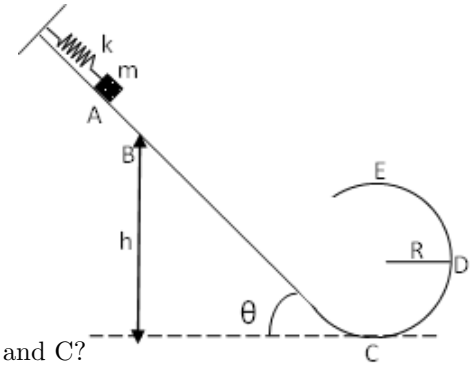
3. What is the acceleration at t=0?
(a) 10 m/s^2 (b) 2 m/s^2 (c) 4 m/s^2 (d) 5 m/s^2 (e) 6 m/s^2

4. What is the acceleration when the speed is 0.15 m/s?
(a) 7 m/s^2 (b) 6 m/s^2 (c) 10 m/s^2 (d) 4 m/s^2 (e) 5 m/s^2

5. What is the net force acted on the material when the speed is 0.15 m/s?
(a) 21 N (b) 15 N (c) 18 N (d) 30 N (e) 12 N

Questions 6-10

A block of mass m is placed in front of a spring which is compressed as x (between points A and B) and the system is set on an inclined surface as in the figure. The rail between A and B, and the circular part (of radius R) between C and E are frictionless (no friction). The region between B and C is considered as a completely flat surface of kinetic friction constant , μ_k. When the spring is released the block leaves the spring and moves along the rail between the points A and E. It passes the point E without falling down. (Take the gravitational acceleration as g)



6. What is the speed of the block at point B?
(a) $v = \sqrt{2gx\sin\theta}$
(b) $v = \sqrt{\frac{1}{2}kx}$
(c) $v = \sqrt{\frac{2}{m}(mgx\sin\theta - \frac{1}{2}kx^2)}$
(d) $v = \sqrt{\frac{2}{m}(mgx\sin\theta + \frac{1}{2}kx^2)}$
(e) $v = \sqrt{\frac{2}{m}(\frac{1}{2}kx^2 - mgx\sin\theta)}$

7. What is the energy lost in the mechanical energy of the block between the points B and C?
(a) zero (b) $\mu_k mgh\cot\theta$ (c) $\mu_k mgh\tan\theta$ (d) $\mu_k\frac{1}{2}kx^2$ (e) $\mu_k mgh\sin\theta$

8. What is the kinetic energy of the block at point C?
(a) $\sqrt{mgh(1-\mu_k)+\frac{1}{2}kx^2}$ (b) mgh (c) $mgh(1-\mu_k)-\frac{1}{2}kx^2$ (d) $mgh(1+\mu_k)+\frac{1}{2}kx^2$ (e) $mg(h+x\sin\theta-\mu_k h\cot\theta)+\frac{1}{2}kx^2$

9. What is the kinetic energy of the block at point E?
(a) $\frac{1}{2}(mgh(1-\mu_k)+\frac{1}{2}kx^2+mg2R)$ (b) $\frac{1}{2}(mgh(1+\mu_k)+\frac{1}{2}kx^2+mg2R)$ (c) $\frac{1}{2}(mgh(1-\mu_k)-\frac{1}{2}kx^2-mg2R)$
(d) $mg(h+x\sin\theta-\mu_k h\cot\theta-2R)+\frac{1}{2}kx^2$ (e) $\frac{1}{2}(mgh(1+\mu_k)+\frac{1}{2}kx^2-mg2R)$

10. What is the normal force on the block applied by the rail at the point E?
(a) $\frac{m}{2R}(mgh(1-\mu_k)-\frac{1}{2}kx^2-mg2R)-mg$ (b) $\frac{2}{R}(mg(h+x\sin\theta-\mu_k h\cot\theta-2R)+\frac{1}{2}kx^2)-mg$ (c) $\frac{m}{2R}(mgh(1-\mu_k)+\frac{1}{2}kx^2-mg2R)+mg$ (d) $\frac{m}{2R}(mgh(1-\mu_k)+\frac{1}{2}kx^2+mg2R)-mg$ (e) $\frac{m}{2R}(mgh(1+\mu_k)+\frac{1}{2}kx^2-mg2R)-mg$

Questions 11-15

A 3.0 kg object has the following two forces acting on it: $\vec{F_1} = (16\hat{\imath} + 12\hat{\jmath})$ N and $\vec{F_2} = (-10\hat{\imath} + 21\hat{\jmath})$ N. The object is initially at rest at a point given by the coordinates (x = 3 m, y = 4 m).

11. What is the magnitude of acceleration of the object?
(a) 6 m/s^2 (b) 12 m/s^2 (c) $5\sqrt{5}$ m/s^2 (d) 11.75 m/s^2 (e) 11 m/s^2

12. What is the momentum change in 4 s?

(a) $(8\hat{\imath}+44\hat{\jmath})$ N·s (b) $(3\hat{\imath}+4\hat{\jmath})$ N·s (c) $(6\hat{\imath}+33\hat{\jmath})$ N·s (d) $(24\hat{\imath}+132\hat{\jmath})$ N·s (e) $(2\hat{\imath}+44\hat{\jmath})$ N·s

13. What is the velocity of the object at t = 2 s?

(a) $(2\hat{\imath}+44\hat{\jmath})$ m/s (b) $(4\hat{\imath}+22\hat{\jmath})$ m/s (c) $(3\hat{\imath}+4\hat{\jmath})$ m/s (d) $(6\hat{\imath}+33\hat{\jmath})$ m/s (e) $(8\hat{\imath}+24\hat{\jmath})$ m/s

14. What is the position vector of the object at t = 2 s?

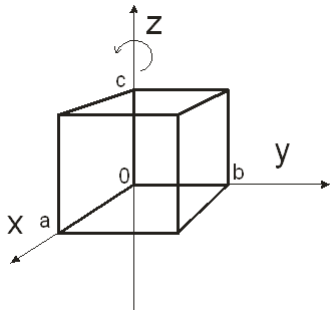
(a) $(7\hat{\imath}+26\hat{\jmath})$ m (b) $(10\sqrt{5}\hat{\imath}+10\hat{\jmath})$ m (c) $(4\hat{\imath}+72\hat{\jmath})$ m (d) $(4\hat{\imath}+88\hat{\jmath})$ m (e) $(8\hat{\imath}+132\hat{\jmath})$ m

15. What is the average velocity of the object between t = 2 s and t = 3 s?

(a) $(12\hat{\imath}+66\hat{\jmath})$ m/s (b) $(5\hat{\imath}+27.5\hat{\jmath})$ m/s (c) $(4\hat{\imath}+88\hat{\jmath})$ m/s (d) $(8\hat{\imath}+24\hat{\jmath})$ m/s (e) $(6\hat{\imath}+8\hat{\jmath})$ m/s

Questions 16-20

A rectangular prism with a mass M = 3 kg rotates in a coordinate system as shown in the figure. The lengths of the sides are a = 1 m, b = 2 m, and c = 3 m. The prism has an angular velocity $w = 2 + 3\ t^2 - 2\ t^3$ about +z-axis in units of rad/s.



16. Find the rotational inertia about z-axis in kgm^2?

(a) 21 (b) 7 (c) 5 (d) 10 (e) 42

17. Find the rotational inertia about axis through the center of mass and parallel to the z-axis.

(a) 10 kgm^2 (b) 21 kgm^2 (c) 5/4kgm^2 (d) 12 kgm^2 (e) 14 kgm^2

18. What is the angular displacement of the point given by the coordinates (x = 1 m, y = 2 m, z = 3 m) between t = 0 s and t = 2 s?

(a) 3 rad (b) 0 rad (c) 5 rad (d) 4 rad (e) 2 rad

19. What is the magnitude of the tangential acceleration of the point given by the coordinates (x = 1 m, y = 2 m, z = 3 m) at t = 2 s in m/s^2?

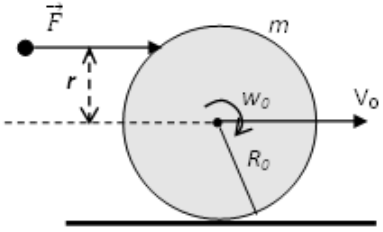
(a) $4\sqrt{5}$ (b) $4\sqrt{2}$ (c) $12\sqrt{5}$ (d) $18\sqrt{5}$ (e) $8\sqrt{5}$

20. What is the kinetic energy of the rectangular prism at t = 2 s?

(a) 14 J (b) 21 J (c) 16 J (d) 18 J (e) 10 J

Questions 21-25

A force $\vec{F} = F\hat{\imath}$ is applied only for a short time at a point above the center of a sphere and transfers a net linear momentum $\vec{p} = p\hat{\imath}$ to the sphere in the x-direction. Ignore any frictional force during the application of the force $\vec{F} = F\hat{\imath}$, and consider that the only force is the frictional force for t≥0. The sphere has a mass m and radius R_0. The sphere is at rest initially. The point to which the force applied is $r = \frac{3}{10}R_0$ above the center of mass of the sphere. The magnitude of the net frictional force for the sphere is $F_k = \mu mg$ where μ is the kinetic friction coefficient between the surfaces. The moment of inertia about an axis passing through the center of mass of the sphere is given by $I = \frac{2}{5}mR_0^2$. The directionof +z-axis is out of the page.



21. What is the speed of the center of mass of the sphere just after the application of the force? $(V_0 = V(t=0) = ?)$

(a) $\frac{2p}{m}$ (b) $\frac{p}{m}$ (c) $\frac{m}{p}$ (d) $\frac{p^2}{2m}$ (e) $\frac{p}{2m}$

22. What is the angular speed about the axis passing through the center of mass just after the application of the force? $(w_0 = w(t=0) = ?)$

(a) $\frac{4mR_0}{3p}$ (b) $\frac{3}{4}\frac{p}{mR_0}$ (c) $\frac{mR_0}{p}$ (d) $\frac{4}{3}\frac{p}{mR_0}$ (e) $\frac{p}{mR_0}$

23. What is the velocity of the center of mass as function of time? $(\vec{V}(t) = ?)$

(a) $\left(\frac{p}{2m} - \mu gt\right)\hat{\imath}$ (b) $\left(\frac{p}{2m} - 2\mu gt\right)\hat{\imath}$ (c) $\left(\frac{2p}{m} - \mu gt\right)\hat{\imath}$ (d) $\left(\frac{p}{m} - 2\mu gt\right)\hat{\imath}$ (e) $\left(\frac{p}{m} - \mu gt\right)\hat{\imath}$

24. What is the angular velocity about the axis passing through the center of mass as function of time? $(\vec{w}(t) = ?)$

(a) $-\left(\frac{3}{4}\frac{p}{mR_0} + \frac{5\mu g}{2R_0}t\right)\hat{k}$ (b) $-\left(\frac{p}{mR_0} + \frac{5\mu g}{4R_0}t\right)\hat{k}$ (c) $-\left(\frac{4}{3}\frac{p}{mR_0} + \frac{4\mu g}{5R_0}t\right)\hat{k}$ (d) $-\left(\frac{3}{4}\frac{p}{mR_0} + \frac{\mu g}{R_0}t\right)\hat{k}$ (e) $-\left(\frac{4mR_0}{3p} + \frac{5\mu g}{4R_0}t\right)\hat{k}$

25. At t=0 the sphere is slipping on the surface. Find the value of t for the sphere to start rolling without slipping?

(a) $\frac{p}{\mu g}$ (b) $\frac{p}{14m\mu g}$ (c) $\frac{p}{m\mu g}$ (d) $\frac{p}{m\mu}$ (e) $\frac{9p}{m\mu g}$