		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 consideration.

Questions 1-2

1. A ball collides with a second ball at rest. After the collision, the first ball comes to rest and the second ball moves off. Which of the following is *always* correct?
(a) If the masses are equal both total momentum and total kinetic energy are conserved.
(b) Total kinetic energy is not conserved.
(c) Total momentum is conserved but total kinetic energy is not conserved.
(d) Total momentum is not conserved.
(e) Total momentum is not conserved but total kinetic energy is conserved.

2. The center of mass of Earth's atmosphere is:
(a) near the outer boundary of the atmosphere
(b) a little more than halfway between Earth's surface and the outer boundary of the atmosphere
(c) near the center of Earth
(d) a little less than halfway between Earth's surface and the outer boundary of the atmosphere
(e) near the surface of Earth

Questions 3-4

A car including the driver and some objects has total mass M and is moving with speed V on a straigth road. What is the speed of the car immediately after the driver throws an object of mass m *backwards* with speed V

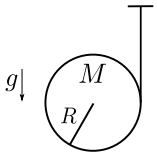
3. *with respect to the ground*?
(a) $(M+m)V/M$ (b) $MV/(M+m)$ (c) $MV/(M-m)$ (d) $(M+m)V/(M-m)$ (e) MV/m

4. *with respect to the car*?
(a) $(M+m)V/M$ (b) MV/m (c) $(M+m)V/(M-m)$ (d) $MV/(M+m)$ (e) $MV/(M-m)$

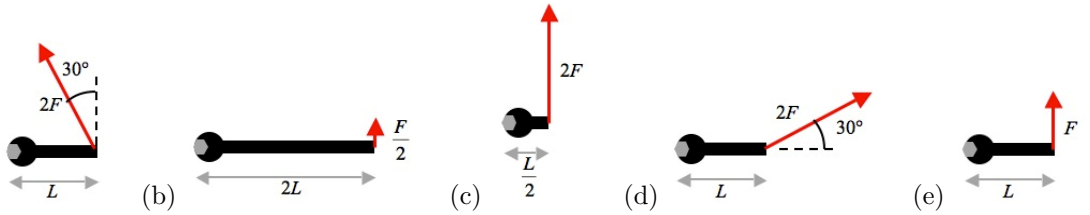
Questions 5-10

5. A wheel of radius 0.5 m rolls without slipping on a horizontal surface. Starting from rest, the wheel moves with constant angular acceleration 6 rad/s^2. What is the distance travelled by the center of the wheel from t=0 to t=3 s?
(a) 18 m (b) 0 m (c) 27 m (d) 13.5 m (e) 9 m

6. What is the tension in the string for the basic yo-yo in the figure?
(a) $Mg/3$ (b) $3Mg/2$ (c) $2Mg$ (d) $3Mg$ (e) Mg

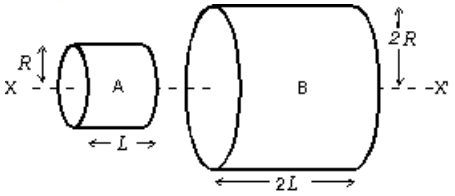


7. A series of wrenches of different lengths is used on a bolt, as shown below, Which combination of wrench length and Force applies the greatest torque to the bolt?

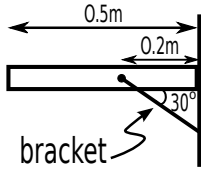


(a) (b) (c) (d) (e)

8. A and B are two solid cylinders made of aluminum. Their dimensions are shown in the figure. The ratio of the rotational inertia of B to that of A about the common axis X-X' is:
(a) 32 (b) 2 (c) 24 (d) 8 (e) 4



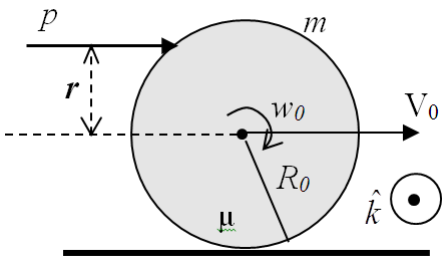
9. A uniform shelf having a weight of 40 N and of depth 0.50 m is supported by a bracket, as shown in the figure. What is the vertical component of the force exerted by the bracket exert on the shelf?
(a) 80 N (b) 50 N (c) 40 N (d) 120 N (e) 60 N



10. An object at the surface of Earth (at a distance R_E from the center of Earth) weighs 90 N. Its weight at a distance $3R_E$ from the center of Earth is: (a) 810 N (b) 270 N (c) 10 N (d) 30 N (e) 90 N

Questions 11-15

A force parallel to the x-axis is applied in a very short time at a point r above the center of a sphere and transfers a net momentum p to the sphere in the x-direction. The sphere has mass m and radius R_0 and is initially at rest. The point to which the force applied is $r = 3R_0/10$ above the center of mass of the sphere. The coefficient of kinetic friction on the surface is μ. The moment of inertia of the sphere is $I = 2mR_0^2/5$. The direction of the z-axis is out of the page.



11. What is the initial speed of the center of mass of the sphere?
(a) $2p/m$ (b) $p^2/2m$ (c) $p/2m$ (d) p/m (e) p^2/m

12. What is the initial angular speed of the sphere?
(a) $3p/2mR_0$ (b) p/mR_0 (c) $4p/3mR_0$ (d) $3p/4mR_0$ (e) p^2/mR_0

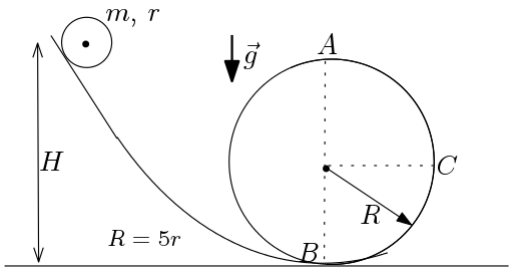
13. What is the velocity of the center of mass of the sphere as function of time?
(a) $(p/m-\mu gt)\hat{\imath}$ (b) $(p/m-\mu gt/2)\hat{\imath}$ (c) $(p/2m-\mu gt)\hat{\imath}$ (d) $(2p/m-\mu gt)\hat{\imath}$
(e) $(p/m-2\mu gt)\hat{\imath}$

14. What is the angular velocity about the center of mass as function of time?
(a) $-(3p/4mR_0+5\mu gt/2R_0)\hat{k}$ (b) $(3p/4mR_0+5\mu gt/2R_0)\hat{k}$ (c) $-(p/mR_0+2\mu gt/5R_0)\hat{k}$ (d) $(4p/3mR_0+5\mu gt/2R_0)\hat{k}$
(e) $-(4p/3mR_0+5\mu gt/2R_0)\hat{k}$

15. The sphere both rotates and slides at the same time in the beginning, therefore slips on the surface for some amount of time. How long does it take until it starts rolling without slipping?
(a) $p/m\mu g$ (b) $p/14\mu g$ (c) $p/14m\mu g$ (d) $14p/mg$ (e) $14p/m\mu g$

Questions 16-20

A uniform disk of mass m and radius r *rolls without slipping* through a loop of radius $R = 5r$, as shown in the figure. The disk is initially at rest at height H. (For the given disk $I_{cm} = mr^2/2$.)



16. What is the minimum value of H, H_{min}, in order to make it through the loop without falling off the track?
(a) $12r$ (b) $14r$ (c) $13r$ (d) $16r$ (e) $17r$

17. If $H = 15r$, what is the speed of the center of the disk at point A?
(a) $\sqrt{5gr/3}$ (b) $\sqrt{8gr}$ (c) $\sqrt{7gr/4}$ (d) $\sqrt{5gr}$ (e) $\sqrt{8gr/5}$

18. If $H = 15r$, what is the normal force on the object at point A?
(a) $4mg/3$ (b) $3mg/2$ (c) $2mg$ (d) $10mg/3$ (e) mg

19. If $H = 15r$, what is the normal force on the object at point C?
(a) $2mg$ (b) $10mg/3$ (c) $4mg/3$ (d) mg (e) $3mg/2$

20. What is the direction and magnitude of the friction force on the disk at point C?
(a) $3mg/4$, downward (b) $mg/3$, upward (c) $2mg/3$, downward (d) $2mg/3$, upward (e) $mg/3$, downward

Questions 21-25

Suppose you want to place a weather satellite with mass m into a circular orbit $R_E/20$ above Earth's surface, R_E being Earth's radius. Take the potential energy reference to be zero at infinity and give yor answers in terms of the parameter $\lambda = GM_E/R_E$ with G_E and M_E being the universal gravitational constant and Earth's mass, respectively.

21. What speed must the satellite have?
(a) $\sqrt{20\lambda/21}$ (b) $\sqrt{20\lambda}$ (c) $\sqrt{10\lambda/11}$ (d) $\sqrt{\lambda}$ (e) $\sqrt{10\lambda}$

22. What radial acceleration must the satellite have?
(a) $100\lambda/R_E$ (b) λ/R_E (c) $400\lambda/R_E$ (d) $(10/11)^2\lambda/R_E$ (e) $(20/21)^2\lambda/R_E$

23. What is the total mechanical energy of the satellite when it is in orbit?
(a) $-\lambda m$ (b) $-5\lambda m/11$ (c) $-10\lambda m$ (d) $-5\lambda m$ (e) $-10\lambda m/21$

24. How much work has to be done to place this satellite in orbit?
(a) $6\lambda m/11$ (b) $11\lambda m$ (c) $2\lambda m$ (d) $11\lambda m/21$ (e) $10\lambda m$

25. How much additional work would have to be done to make this satellite escape the earth?
(a) $5\lambda m/11$ (b) $10\lambda m$ (c) $6\lambda m/11$ (d) $11\lambda m$ (e) $10\lambda m/21$