Name: Term 2 answer keys

ID:

There is a sheet of useful formula and values of constant at the end. Circle your answers clearly. All problems are 3 points each except for problems 3 (5 points) and 24-28 (4 points each). Maximum score for this exam is 100.

1. Consider a massive object in the shape of a ring lying in the x-y plane with its center at the origin. The direction of the gravitational force at the origin due to this ring is
   a. in the positive z direction   b. in the negative z direction
   c. in the positive x direction   **d. the force is zero**

2. Mass of the Earth is $5.98\times10^{24}\,kg$, and the radius of the Earth is $6.38\times10^{6}\,m$. The period of a satellite orbiting the Earth 2000 km above the surface is
   a. $3.5\times10^{3}s$ **b.** $7.6\times10^{3}s$
   c. $8.5\times10^{3}s$ d. $9.0\times10^{3}s$

3. Four masses of 1kg , 2kg, 3kg and 4kg are on an x-y plane. Their coordinates are (1,1), (2,0), (0,1) and (0,0) whose side is 0.5m each. What is the coordinate of the center of mass of this system? [5 points]

$$x_{CM}=\frac{1\cdot1+2\cdot2+3\cdot0+4\cdot0}{1+2+3+4}=\frac{5}{10}=0.5$$

$$y_{CM}=\frac{1\cdot1+2\cdot0+3\cdot1+4\cdot0}{1+2+3+4}=\frac{4}{10}=0.4$$

$$r_{CM}=(0.5,0.4)$$

4. The dot product of vectors **A** and **B** equals 5.4. If A has magnitude 2 and B has magnitude 3.5 then the angle between the two vectors is
   a. 40º   b. 50º
   c. 130º   d. the given information is inconsistent

5. Object A of mass 4 kg moves with a speed 2 m/s. Object B of mass 2 kg moves with speed 4 m/s. Both objects are brought to rest by the same constant force. The object which travels the greater distance while being brought to rest is
   a. object A   **b. object B**   c. both travel the same distance

6. A force accelerates a 5 kg box from a speed of 2.5 m/s to a speed of 4.0 m/s in 5 s. The work done by this force over this time is
   a. 25 J   b. 47 J
   c. 62.5 J   d. more information needed

7. A box is given an initial velocity of 5 m/s. It slides across a rough surface coming to rest in 2 m. The coefficient of kinetic friction is
   a. 0.2   b. 0.4
   c. 0.6   d. 0.7

8. A block of mass 10 kg is attached to a spring with spring constant 1000 N/m. The spring is compressed 2 cm and released from rest. The speed of the block as it passes through the equilibrium position of the spring is
   a. 0.2 m/s b. 0.4 m/s
   c. 0.6 m/s d. 0.8 m/s

9. A box is given an initial velocity of 5 m/s. It slides across a rough surface coming to rest in 2 m. The mass of the box is
   a. 5 kg b. 10 kg
   c.25 kg **d. not enough information provided**

10. A block of mass 5 kg starts from rest at the top of a ramp which is 5 m high. It descends to the bottom of the ramp and then rises to the top of a second ramp which is 2.5 m high. The speed of the block at the top of the second ramp is
    a. 3.5 m/s **b. 7 m/s**
    c. 14 m/s d. 21 m/s

11. Two masses are released from rest at the top of frictionless inclined planes of the same height but different angles. Which mass is moving faster at the bottom of the incline?
    a. the one on the steeper incline b. the one on the shallower incline
    c. both have the same speed d. we need to know the values of the masses and angles

12. A 5 kg block slides on a rough horizontal surface with speed 2.0 m/s. It makes contact with a spring and momentarily stops when the spring is compressed 5 cm. The work done by friction from the moment the block contacts the spring until it momentarily stop s is -2.0 J. The spring constant of the spring is
    a. 2000 N/m b. 4000 N/m
    c. 6400 N/m d. 9600 N/m

13. An object of mass 5 kg is dropped from a height of 25 m and strikes the ground with a speed of 5 m/s. The average force of air resistance on this object is
    a. 24 N **b. 47 N**
    c. 54 N d. 98 N

14. An object moves with a potential energy given by $U(x) = 2x^2$. The maximum kinetic energy of the object is
    a. 1.125 b. 0
    c. 2 **d. not enough information**

15. The equilibrium position of the object in the above problem is located at
    a. x = 0 b. x = -0.5
    c. x = -1.25 d. x = -2

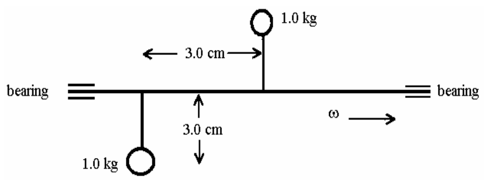
16. The equilibrium position located in the above problem is
    a. stable b. unstable c. not enough information

17. Assume a rocket is far enough in space that the acceleration due to gravity is negligible. If the mass ratio, initial mass/final mass, changes from 10 to 20 for the same exhaust velocity, by what factor does the increase of velocity change?
    a. 2.0 b. 0.50
    c. 0.69 **d. 1.3**

18. In all types of collisions (elastic, inelastic and perfectly inelastic) linear momentum is always conserved:
    a. true b. false

19. A force is applied to the rim of a 20. cm diameter wheel. The radial component is 7.00 N and the tangential component is 14.0 N. What is the torque?
    a. 0.70 N-m　　　**b. 1.4 N-m**
    c. 0.35 N-m　　　d. 2.1 N-m

20. A spherical orbiting spacecraft with a moment of inertia of 15. kg-m^2 and spinning at 10. rad/s slows down to 5.0 rad/s in one year. What is the average retarding torque exerted on the craft during the time period?
    a. $0.6\times10^{-6} N\cdot m$　　　b. $1.2\times10^{-6} N\cdot m$
    c. $2.4\times10^{-6} N\cdot m$　　　d. $4.8\times10^{-6} N\cdot m$



21. Two 1.0 kg masses are positioned 3.0 cm from a rotational axis as shown in the picture above. If the rod rotates 700. rpm, what is the magnitude of the torque exerted on the bearings (**no answer for this problem**)?
    a.6.9 N-m　　　b. 7.7 N-m
    c.9.5 N-m　　　d. 10.3 N-m

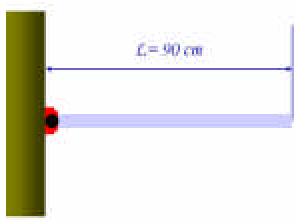
22. What is the quantity used to measure an object's resistance to changes in rotation?

    a) mass　　　**b) moment of inertia**　　　c) torque　　　d) angular velocity

23. A triatomic molecule is modeled as follows: mass m is at the origin, mass 2m is at x = a, and, mass 3m is at x = 2a. What is the moment of inertia about the origin?

    a. 2 m a^2　　　b. 3 m a^2　　　c. 12 m a^2　　　**d. 14 ma^2**

A uniform rod of length 90.0 cm and mass 1.80kg is attached at one end to a frictionless pivot and is free to rotate about the pivot in the vertical plane, as shown in the figure. Answer the following series of questions, assuming that the rod is released from rest in the horizontal position, and the magnitude of the gravitational acceleration g is $9.80 m/s^2$.



24. What is the line density of the rod? (4 points)
    a. 2.50kg/cm^3　　**b. 2.00kg/m**　　c. 2.00kg/cm　　d. 2.50kg/m^3

25. What is the moment of inertia of the rod in this motion? (4 points)
    a. $0.486 kg\cdot m^2$　　b. $1.62 kg\cdot m$　　c. $1.46 kg\cdot m^2$　　d. $0.12 kg\cdot m^2$

26. What is the initial angular acceleration of the rod? (4 points)
    a. $14.6 m/s^2$　　b. $16.3 m/s^2$　　c. $1.62/s^2$　　**d.** $16.3/s^2$

27. What is the initial linear acceleration in the middle of the rod? (4 points)
    a. $16.3 m/s^2$　　**b.** $7.35 m/s^2$　　c. $8.15 m/s^2$　　d. $8.15/s^2$

28. What is the magnitude of torque? (4 points)
    a. $23.6 N$　　b. $1.96 N\cdot m$　　**c.** $7.92 N\cdot m$　　d. $17.8 N$

29. Fill in the following table. You must write both the name and the mathematical expression of the quantities. The names and the expression are 0.5 points each. Total for this problem is 9 points.

Quantities	Linear Motion	Rotational Motion	
		Name	Expression
Mass	M	**Moment of Inertia**	$I = \int_{r_i}^{r_f} r^2 dm$
Displacement	$\vec{r}$	**Angular Displacement**	$\Delta q = q_f - q_i$
Velocity	$\vec{v} = \frac{d\vec{r}}{dt}$	**Angular speed**	$\vec{v} = \frac{dq}{dt}$
Acceleration	$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$	**Angular acceleration**	$a = \frac{dv}{dt} = \frac{d^2q}{dt^2}$
Force	$\vec{F} = m\vec{a}$	**Torque**	$\vec{t} = I\vec{v} = \vec{r} \times \vec{F}$
Work	$W = \int_{r_i}^{r_f} \vec{F} \cdot d\vec{r}$	**Work**	$W = \int_{r_i}^{r_f} \vec{t} \cdot d\vec{q}$
Power	$P = \vec{F} \cdot \vec{v}$	**Power**	$P = \vec{t} \cdot \vec{v}$
Momentum	$\vec{p} = m\vec{v}$	**Angular Momentum**	$\vec{L} = I\vec{v}$
Kinetic Energy	$K = \frac{1}{2}mv^2$	**Rotational Kinetic Energy**	$K = \frac{1}{2}Iv^2$

Turn Over