Potentially useful information:

$g = 9.8 \text{ m/s}^2$

$\vec{A} \bullet \vec{B} = A_x B_x + A_y B_y + A_z B_z$

If acceleration a_x is constant, then:

$$v_x = v_{xo} + a_x t$$

$$x = x_o + v_{xo} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = v_{xo}^2 + 2a_x (x - x_o)$$

If a_y is a function of time, a(t), then:

$$v_y(t) = v_{yo} + \int_o^t a(t)dt$$

$$y(t) = y_o + \int_o^t v_y(t)dt$$

$a_c = -\omega^2 r = -v^2/r$

- $F_{fr} = \mu F_N$
- $F = -\frac{dU}{dx}$
- $M\left(\frac{dv}{dt}\right) = v_{rel}\left(\frac{dM}{dt}\right)$
- $W = \int \vec{F} \cdot d\vec{s}$
- $P = \frac{dE}{dt} = \vec{F} \bullet \vec{v}$
- $F = -\frac{Gm_1 m_2}{r_{12}^2}$
- $U = -\frac{Gm_1 m_2}{r_{12}}$
- $G = 6.7 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
- $K = \frac{1}{2} I\omega^2 + \frac{1}{2} mv^2$
- $\vec{\tau} = \vec{r} x \vec{F}$
- $\vec{\tau} = I\vec{\alpha}$ [fixed axis]
- $\vec{L} = I\vec{\omega}$ [fixed axis]
- $W = \int \tau d\theta$
- Moments of inertia

Rod (about center):	$I = (1/12)ML^2$
Hoop	$I = MR^2$
Uniform disk:	$I = (1/2)MR^2$
Sphere:	$I = (2/5)MR^2$

Figure 1.

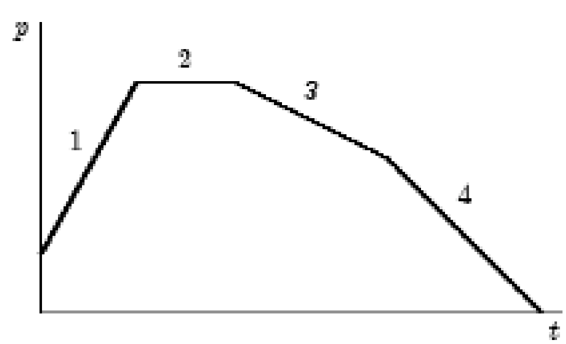

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Figure 2.

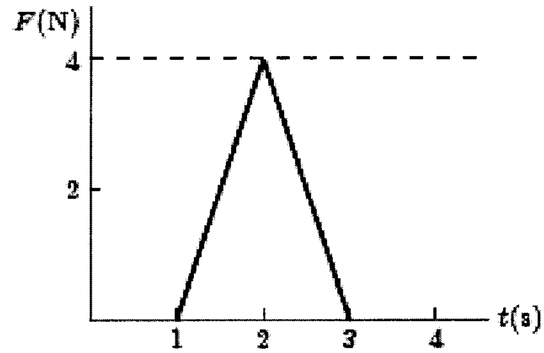


Figure 3.

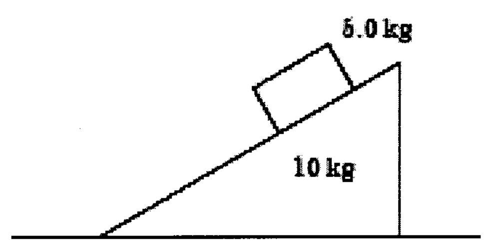


Figure 4.

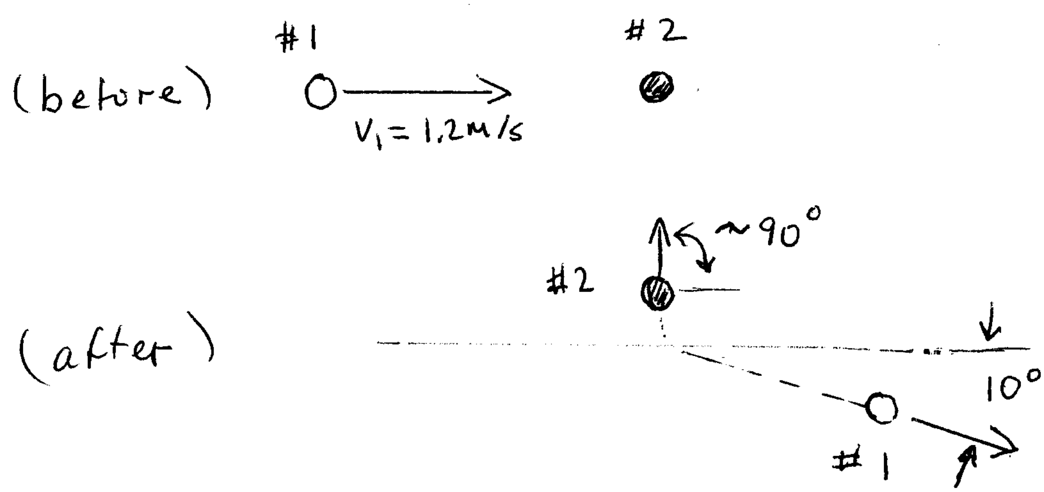


Figure 5.

(horizontal arrows indicate disks being pushed together)

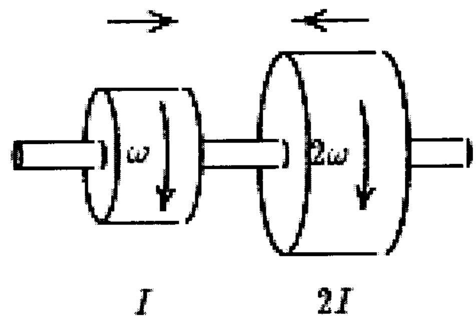
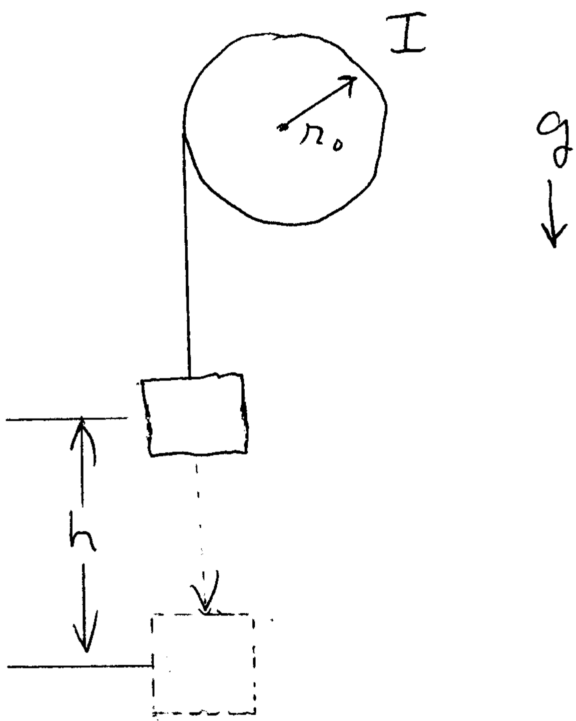


Figure 6.



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Be sure to indicte your Code Number and the Test Form on the front of your Blue Book
The Test Form is indicated on the bottom of this page.

Please see preceeding page for potentially useful formulae. This exam contains 10 problems.

Problems 1 - 5, inclusive count 4 points each; and problems 6 - 10 count 8 points each.

Partial credit will be given for Problems 6 - 10, so please show your work clearly.

There will be no partial credit for problems 1 - 5.

Please put the answers to problems 1 - 5 on the first page inside your blue book.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Please note: If no answer is correct, choose the answer that is closest.

1) A woman is sitting in the back of a canoe in still water. She then moves to the front of the canoe and sits down. Afterwards the canoe is
   A) forward of its original position and moving forward
   B) forward of its original position and moving backward
   C) rearward of its original position and moving forward
   D) rearward of its original position and moving backward
   E) rearward of its original position and not moving

2) This problem relates to Figure 1 on the formula pages. The momentum is shown as a function of time for a particle moving along the x axis. Rank the numbered regions according to the magnitude of the force acting on the particle, least to greatest.
   A) 1, 2, 3, 4 B) 2, 3, 4, 1 C) 1, 4, 3, 2 D) 1, 3, 4, 2 E) 2, 4, 3, 1

3) This problem relates to Figure 2 on the formula pages. An object with a mass of 5 kg can move frictionlessly in the x direction. It is subject to a force F (given in N) in the +x direction, which is shown in the figure as a function of time. If the object is initially at rest, its final velocity will be:
   A) 0.8 B) 1.1 C) 1.6 D) 2.3 E) 4.0

4) A hoop (i.e., a cylinder with all the mass at the rim) rolls on a horizontal surface without slipping. The rotational kinetic energy of the hoop is
   A) half its translational kinetic energy
   B) twice its translational kinetic energy
   C) the same magnitude as its translational kinetic energy
   D) four times its translational kinetic energy
   E) one third of its translational kinetic energy

5) A rocket in outer space is traveling at 2500 m/s and exhausting fuel at a rate of 100 kg/s. If the speed of the exhausting fuel leaving the rocket is 1500 m/s relative to the rocket, what is the magnitude of the thrust (in N) that accelerates the rocket?
   A) 2.5×10^5
   B) 1.5×10^4
   C) 3.75×10^6
   D) 1.5×10^5
   E) Insufficient information is given to answer this problem.

<u>The following questions are not multiple choice. Please show your work in addition to the answer in your blue book.</u>

6) <u>This problem relates to Figure 3 on the formula pages.</u> A large wedge of mass 10 kg rests on a horizontal frictionless surface as shown. A block with a mass of 5.0 kg starts from rest and slides down the inclined surface of the wedge which is rough. At one instant the vertical component of the block's velocity is 3.0 m/s and the horizontal component is 6.0 m/s. What is the velocity of the wedge at this time, both in magnitude and direction (i.e., to the left or the right)?

7) <u>This problem relates to Figure 4 on the formula pages.</u> Two billiard balls with equal masses make an elastic collision. Ball number 2 is initially at rest. It is struck by ball number 1 which is initially traveling at a velocity $v_1 = 1.2$ m/s. Ball number 1 is scattered at a small angle $\theta_1 = 10^o$ as shown, and ball number 2 travels at approximately 90^o with respect to the initial velocity of ball number 1. What is the approximate final velocity, v_2, of ball number 2.

8) A uniform solid disk of mass m = 2 kg rolls on a horizontal surface without slipping. When subject to an external force, it accelerates at a rate a = 3 m/s^2. What is the magnitude of the applied force, F, and what is the magnitude of the frictional force, F_{fr}, that keeps the disk from slipping?

9) <u>This problem relates to Figure 5 on the formula pages.</u> Two disks are mounted on frictionless bearings on a common shaft as shown. The first disk has moment of intertia I and is spinning at angular velocity ω. The second disk has moment of intertia 2I and is spinning in the same direction at angular velocity 2ω. The disks are then forced together until they couple. What is the final angular velocity of the two-disk combination?

10) This problem relates to Figure 6 on the formula pages. A mass m is connected to a string wound around a cylinder with moment of intertia I and radius r_o. If the cylinder rotates frictionlessly and the mass is released from rest, what is the speed of the mass after it has descended a distance h?

Answer Key
Testname: GF 4.3.6

1) E
2) B
3) A
4) C
5) D
6) No Correct Answer Was Provided.
7) No Correct Answer Was Provided.
8) No Correct Answer Was Provided.
9) No Correct Answer Was Provided.
10) No Correct Answer Was Provided.