

Exam Code: make-up

Seat Number _____

The University of Western Ontario,
Physics 1026 Mid-Year Examination
January 9, 2009

Print NAME _____

Student Number _____

Circle your section number.

Section 1	Lectures on Tuesdays and Thursdays
Section 2	Lectures on Mondays and Wednesdays

Please read the following notes and ensure that you have carried out all instructions. There are TWO pages of instructions. Read them both!

1. Make sure that you are sitting in your assigned seat. Failure to do this will result in a grade of zero. If you have been asked to change your seat write your new seat number on the front page
2. Verify that this exam booklet contains 17 pages, including the cover page and equation sheets.
3. Detach the equation sheets (2) for easy access.
4. Print your **NAME** and **STUDENT NUMBER** at the top of this page, and **circle** your section number. If your name and/or student number are illegible, there is no way for you to be identified, and you will receive **zero** for the exam.
5. Circle all answers in **part I** (multiple choice) in the exam booklet.

PART II	1	2	3	4	5	6	7	Total
Maximum Mark	4	6	8	6	6	8	12	50
Mark Awarded								

6. Answer **all** questions in **part II** in this exam booklet. Where answer boxes are provided, use them. Show your working in the area adjacent to the answer boxes, but NOT inside them (unless otherwise specified).
7. You may NOT have any notes or sheets with you during the examination other than items attached to this examination sheet.
8. The only calculators that can be used during this exam are SHARP EL-510RB calculators. No exceptions. Other calculators will be confiscated by the proctors and may be picked up after the exam is over. No PDAs, computers, cell phones, or other electronic devices may be accessible to you during this exam, nor may they be turned on. If found in your vicinity, such devices will be confiscated. They may be collected after the exam.
9. When you are finished your examination, pass your paper to a proctor, or place it in the place allocated by the proctors. Be sure to **hand in the exam, the scantron sheet and the equation sheet**. If the proctors issue alternative instructions, they will take precedence over these written instructions. Listen carefully to any instructions given.
10. Interpret phrases such as “None of the above” to mean “None of the other choices given in this question”.

PART I – MULTIPLE CHOICE (50% of exam total)

Answer **all** of the following **25** questions on the **scantron sheet**. All questions have equal weight. **Total value = 50 points.**

1. The coordinates of a particle in meters is given by $x(t) = 25 + 64t - 12t^3$, where the time t is in seconds. To two significant figures, the particle is momentarily at rest at $t =$

- A) 0.43 s
- B) 1.3 s
- C) 2.3 s
- D) 5.3 s
- E) 9.3 s

2. A stone is released from a balloon that is going up at a constant speed of 5 m/s. Neglecting air resistance, after 5 s the speed of the stone is:

- A) 216 m/s
- B) 176 m/s
- C) 44 m/s
- D) 54 m/s
- E) 18 m/s

3. If $\vec{A} = (6m)\hat{i} + (8m)\hat{j}$ then $5\vec{A}$ has magnitude:

- A) 40 m
- B) 10 m
- C) 50 m
- D) 30 m
- E) 20 m

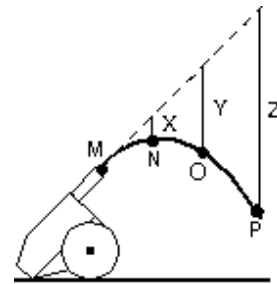
Part I, ctd...

4. Vectors \vec{A} and \vec{B} each have magnitude L . When drawn with their tails at the same point, the angle between them is 60° . The magnitude of $\vec{A} \times \vec{B}$ is:

- A) $\sqrt{3} L^2/2$
- B) L^2
- C) $L^2/2$
- D) $2 L^2$
- E) None of the above

5. A cannon fires a projectile as shown. The dashed line shows the trajectory in the absence of gravity; points MNOP correspond to the position of the projectiles at two second intervals. If $g = 10 \text{ m/s}^2$, the lengths X, Y, Z are:

- A) 10 m, 40 m, 90 m
- B) 20 m, 80 m, 180 m
- C) 20 m, 40 m, 90 m
- D) 10 m, 20 m, 30 m
- E) 0.2 m, 0.4 m, 1.8 m



6. A stone is tied to a string and whirled at constant speed in a horizontal circle. The speed is then increased by factor of three without changing the length of the string. Afterward the magnitude of the acceleration of the stone is:

- A) the same
- B) three as great
- C) nine times as great
- D) half as great
- E) $\sqrt{3}$ times as great

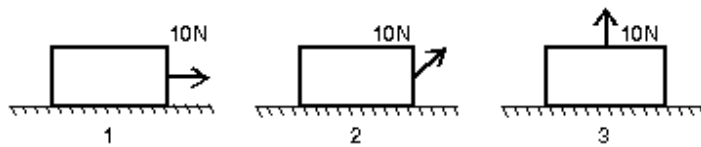
Part I, ctd.

7. A 12-kg object is moving south. A net force of 24 N south on it results in the object having an acceleration of:

- A) 2 m/s^2 , south
- B) 2 m/s^2 , north
- C) 6 m/s^2 , north
- D) 18 m/s^2 , north
- E) 18 m/s^2 , south

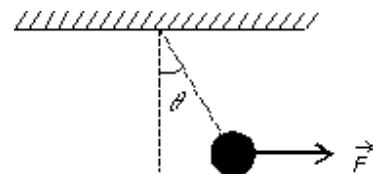
8. A crate rests on a horizontal surface and a woman pulls on it with a 10-N force. Rank the situations shown below according to the magnitude of the normal force exerted by the surface on the crate, greatest to smallest.

- A) 2, 1, 3
- B) 2, 3, 1
- C) 3, 2, 1
- D) 1, 3, 2
- E) 1, 2, 3



9. A 1-N pendulum bob is held at an angle θ from the vertical by a 3-N horizontal force F as shown. The tension in the string supporting the pendulum bob (in newtons) is:

- A) $\cos \Theta$
- B) $2 / \cos \Theta$
- C) $\sqrt{10}$
- D) 1
- E) $\sqrt{6}$



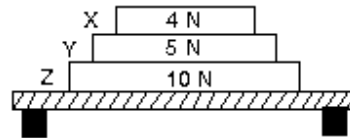
10. A 1000-kg elevator is rising and its speed is increasing at 3 m/s^2 . The tension in the elevator cable is:

- A. 6800 N
- B. 1000 N
- C. 3000 N
- D. 9800 N
- E. 12800 N

Part I, ctd.

11. Three books (X, Y, and Z) rest on a table. The weight of each book is indicated. The reaction force of book Y on book X is:

- A) 4N
- B) 5N
- C) 9N
- D) 14N
- E) 19N



12. A 90-kg man stands in an elevator that has a downward acceleration of 2.8 m/s^2 . The force exerted by him on the floor is about:

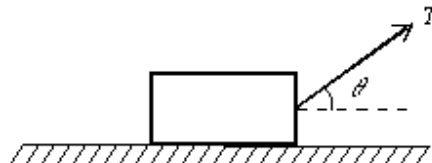
- A) zero
- B) 90 N
- C) 630 N
- D) 760 N
- E) 1130 N

13. The coefficient of kinetic friction:

- A) is in the direction of the frictional force
- B) is in the direction of the normal force
- C) is the ratio of force to area
- D) can have units of newtons
- E) none of the above

14. A block of mass m is pulled at constant velocity along a rough horizontal floor by the rope and applied force \vec{T} as shown. The magnitude of frictional force is:

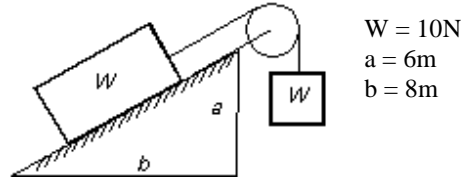
- A) $T \sin \Theta$
- B) $T \cos \Theta$
- C) zero
- D) mg
- E) $mg \cos \Theta$



Part I, ctd.

15. The system shown remains at rest. The force of friction on the upper block is:

- A) 4 N
- B) 8 N
- C) 12 N
- D) 16 N
- E) 20 N



16. A 2-kg object is moving at 3 m/s. A 2-N force is applied in the direction of motion and then removed after the object has traveled an additional 5 m. The work done by this force is:

- A) 10 J
- B) 15 J
- C) 18 J
- D) 20 J
- E) 38 J

17. A baseball player catches a ball of mass m that is moving toward him with speed $2v$. While bringing the ball to rest, his hand moves back a distance d . Assuming constant deceleration, the horizontal force exerted on the ball by his hand is:

- A) mv/d
- B) mvd
- C) $2mv^2/d$
- D) $2mv/d$
- E) $mv^2/(2d)$

18. Energy has the units of:

- A) N
- B) N m^2
- C) N/m^2
- D) N m
- E) None of the above

Part I, ctd.

19. A 10-kg ball is released from rest 90 m above the ground. When it has fallen 60 m its kinetic energy is approximately:

- A) 4800 J
- B) 3500 J
- C) 5880 J
- D) 120 J
- E) 60 J

20. At time $t = 0$ a 2-kg particle has a velocity in m/s of $4\hat{i} - 3\hat{j}$. At $t = 3$ s its velocity is $2\hat{i} + 3\hat{j}$. During this time the work done on it was:

- A. 4 J
- B. - 4 J
- C. - 12 J
- D. - 40 J
- E. $4\hat{i} + 36\hat{j}$ J

21. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the velocity of the center of mass of the two-ball system is:

- A. 11 m/s, down
- B. 11 m/s, up
- C. 15 m/s, down
- D. 15 m/s, up
- E. 20 m/s, down

Part I ctd.

22. A 2.0-kg block is attached to one end of a spring with a spring constant of 100 N/m and a 4.0-kg block is attached to the other end. The blocks are placed on a horizontal frictionless surface and set into motion. At one instant the 2.0-kg block is observed to be traveling to the right with a speed of 0.50 m/s and the 4.0-kg block is observed to be traveling to the left with a speed of 0.30 m/s. Since the only forces on the blocks are the force of gravity, the normal force of the surface, and the force of the spring, we conclude that:

- A) the spring is compressed at the time of the observation
- B) the spring is not compressed at the time of observation
- C) the motion was started with the masses at rest
- D) the motion was started with at least one of masses moving
- E) the motion was started by compressing the spring

23. A wheel starts from rest and has an angular acceleration of 10 rad/s^2 . The time it takes to make 10 revolutions is:

- A) 0.50 s
- B) 0.71 s
- C) 2.5 s
- D) 2.8 s
- E) 5.6 s

24. A point P lies on the +z axis. A force F is applied at this point. In order for the resultant torque to act in the +y direction, in which direction must the force F be applied?

- A) +x
- B) -x
- C) -z
- D) +y
- E) -y

25. A playground merry-go-round has a radius of 3.0 m and a rotational inertia of 600 kg m^2 . It is initially spinning at 0.6 rad/s when a 20-kg child crawls from the center to the rim. When the child reaches the rim the angular velocity of the merry-go-round is:

- A) 0.46 rad/s
- B) 0.62 rad/s
- C) 0.80 rad/s
- D) 0.89 rad/s
- E) 1.1 rad/s

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PART II – PROBLEMS (50% of exam total)

Answer ALL questions. Where answer boxes are provided, use them. Illegible answers will not be marked. Working should be shown in the regions adjacent to the answer boxes. Working and method will be considered in marking your answer.

Space for rough working... (this page will not be marked)

II.1. An object undergoes a displacement (in units of m) $\vec{s} = 3\hat{i} + 2\hat{j}$ while subject to constant forces (in units of N) $\vec{F}_1 = 6\hat{i} + \hat{j}$ and $\vec{F}_2 = \hat{i} + 5\hat{j}$, where \hat{i} and \hat{j} are the usual unit vectors.

- a) Calculate the total force on the object.
- b) Calculate the total work done on the object by these forces.

Place answer here.
(a)
(b)

II.2. An 80 kg person is standing on a scale in an elevator. What does the scale read when

- a) the elevator is ascending at a constant speed of 8.0 m/s?
- b) the elevator is accelerating upwards at 2 m/s^2 ?
- c) the elevator is descending at 10.0 m/s but its speed is decreasing by 2.0 m/s every second?

Place answer here.
(a)
(b)
(c)

II.3. Figure below shows a man sitting in a bosun's chair that dangles from a massless rope, which runs over a massless, frictionless pulley and back down to the man's hand. The combined mass of man and chair is 81.1 kg.

With what force magnitude must the man pull on the rope if he is to rise (a) with a constant velocity and (b) with an upward acceleration of 1.46 m/s^2 ? (*Hint: A free-body diagram can really help.*)

If the man is not holding the rope and the rope on the right extends to the ground and is pulled by a co-worker, with what force magnitude must the co-worker pull for the man to rise (c) with a constant velocity and (d) with an upward acceleration of 1.46 m/s^2 ?



Place answer here.

- (a)
- (b)
- (c)
- (d)

II.4. A 6.0 g bullet moving at 528 m/s strikes a 150 g wooden block at rest on a frictionless surface. The bullet emerges, traveling in the same direction with its speed reduced to 330 m/s.

- (a) What is the resulting speed of the block?
- (b) What is the speed of the bullet-block center of mass?

Place answer here.

(a)

(b)

II.5. A uniform disk of mass $8.00m$ and radius $8.00r$ can rotate freely about its fixed center like a merry-go-round. A smaller uniform disk of mass m and radius r lies on top of the larger disk, concentric with it. Initially the two disks rotate together with an angular velocity of 27.2 rad/s. Then a slight disturbance causes the smaller disk to slide outward across the larger disk, until the outer edge of the smaller disk catches on the outer edge of the larger disk. Afterward, the two disks again rotate together (without further sliding). Hint: use parallel axis theorem.

- (a) What then is their angular velocity about the center of the larger disk?
- (b) What is the ratio K/K_0 of the new kinetic energy of the two-disk system to the system's initial kinetic energy?

Place answer here.

(a)

(b)

II.6. A skier of mass 50.0 kg is standing at the top of a ski hill 100.0 m high.

a) If she starts down with an initial speed of 2.5 m/s, how fast is she going at the bottom of the hill? Neglect friction and air resistance.

b) Now moving horizontally, she crosses a patch of rough snow where friction is no longer negligible and $\mu_k = 0.25$. If the patch is 225 m long, how fast is she going at the end of it? (She doesn't use her poles.)

c) She hits a snowdrift and penetrates 2.0 m into it before coming to a stop. What is the average force exerted on her by the snowdrift as it stops her? (The average force is equivalent to a constant force that would stop her in the same distance.)

(8 points)

Place answer here.

(a)

(b)

(c)

II.7. Two skaters, each of mass 60 kg are holding onto the ends of a pole of length 10 m and negligible mass. Their motion is such that they are rotating without friction about the midpoint of the pole at a rate of 1 revolution in 5 seconds on the horizontal ice surface of a frozen pond. By pulling on the pole the skaters reduce their separation from 10 m to 2 m.

a) Which of the following quantities are conserved for the system:

- Linear momentum
- Angular momentum
- Translational kinetic energy
- Rotational kinetic energy?

b) How long does it now take for them to complete one revolution?

c) How much work did they have to do to reduce their separation to 2m?

(12 points)

Place answer here.
(a)
(b)
(c)

Sample exam - solutions

Part I

1 b; 2 c; 3 c; 4 a; 5 b; 6 c; 7 a; 8 e; 9 c; 10 e; 11 a; 12 c; 13 e; 14 b; 15 a; 16 a; 17 c; 18 d; 19 c; 20 c; 21 c; 22 d; 23 c; 24 a; 25 a

Part II

1

$$a - (7\mathbf{i} + 6\mathbf{j}) \text{ N}$$

$$b - (7\mathbf{i} + 6\mathbf{j}) \cdot (3\mathbf{i} + 2\mathbf{j}) = 21 + 12 = 33 \text{ J}$$

2

$ma = N - mg$ where N is the normal force by the scale on the person

$$a - a = 0, N = mg = 784 \text{ N and } m = 80 \text{ kg}$$

$$b - a = 2 \text{ m/s}^2, N = m(g + a) = 944 \text{ N and } m' = 96.3 \text{ kg}$$

$$c - \text{again, } a = 2 \text{ (m/s)/s} = 2 \text{ m/s}^2 \text{ so } m' = 96.3 \text{ kg as in b}$$

3

Give a radius r at the pulley and write the equilibrium for torques about the center of the pulley: $Fr = mgr$ for case (a) and $Fr = m(g+a)r$ for case (b).

(c) and (d): is there any difference from case (a) and (b) respectively?

4

a - Use expressions for elastic scattering on a target

$$b - \text{Use } m_1 v_{i1} + m_2 v_{i2} = M_{\text{tot}} v_{\text{com}}$$

5

a - Write the MoI I_b before the drift as the sum of the MoIs of the two disks I_1 and I_2

Write the MoI $I_{b'}$ after the drift as the sum of I_1 and I_2' (the MoI of the 2nd disk increased by the parallel axis theorem where $h = 7r$)

Use the conservation of angular momentum $w I_b = w' I_{b'}$ and determine w'

$$b - K_o = \frac{1}{2} I_b w \text{ and } K = \frac{1}{2} I_{b'} w'$$

6

Use conservation of mech. energy and get $v_i = 38.4 \text{ m/s}$;

Determine work done by friction and write the change in mech. energy and determine the change in final KE: $v_f = 19.3 \text{ m/s}$;

Add the work done by the snowdrift, write it as force \times displacement (2 m) and get $c = 5.61 \text{ kN}$

7

$$w_o = 2\pi/5 \text{ rad/s}$$

$$I_o = m_1 R_o^2 + m_2 R_o^2 = 625 \text{ kg m}^2$$

$$I_f = 100 \text{ kg m}^2$$

$$w_o \cdot I_o = w_f \cdot I_f. \text{ Therefore } w_f = 7.88 \text{ rad/s and } T = 2\pi/w_f = 0.8 \text{ s}$$

$$W = K_{ef} - K_{Eo} = \frac{1}{2} I_f w_f^2 - \frac{1}{2} I_o w_o^2 = 2590 \text{ J}$$