Family Name:_____ Given Name:_____ Student number: _____

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- speaking or communicating with other students who are writing examinations.
- copying from the work of other candidates or purposely exposing written papers to the view of other candidates.

Question #	Mark	Maximum Mark
Multiple Choice		20
11		10
12		10
13		10
14		10

Total = /60

Enter your answers to the multiple choice questions here by blackening in the circle corresponding to the best answer. There is only one correct answer per question.

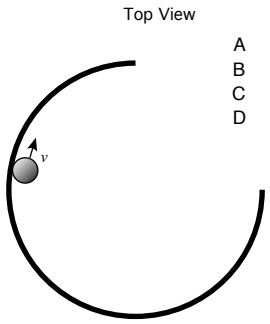
1. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
4. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
5. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
6. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
8. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
9. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
10. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

There are 10 multiple choice questions. Select the correct answer for each one and mark it on the bubble form on the cover sheet. Each question has only one correct answer. (2 marks each)

1. Two balls are moving with respect to each other along the x axis. With respect to the earth's frame of reference the red ball is moving at $v_{r,e} = +5$ m/s and the blue ball is moving at $v_{b,e} = -3$ m/s. What is the velocity of the blue ball with relative to the red ball, $v_{b,r}$?

   (a) +8 m/s
   (b) −8 m/s Correct
   (c) +2 m/s
   (d) −2 m/s
   (e) Cannot answer without knowing more information

2. A marble is rolling inside and around a circular hoop. A portion of the hoop is removed and as the marble leaves the restraint of the hoop which of the letters lies on the path of the marble?



   (a) A
   (b) B correct
   (c) C
   (d) D
   (e) Cannot answer without knowing more information.

3. A box is sitting on the bed of a moving truck. The work done by static friction on the box while *stopping* is

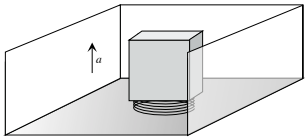
   (a) zero.
   (b) positive.
   (c) negative. correct
   (d) will depend on the directions that are defined to be positive and negative.

4. What is the dot product of two vectors $\vec{A}$ and $\vec{B}$ that have an angle of $\theta = 30°$ between them?

   (a) AB
   (b) $AB \sin 30°$
   (c) $AB \sin 60°$ Correct:
   (d) 0
   (e) None of the above.

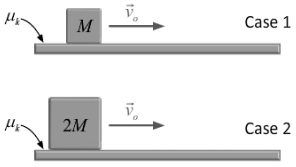
   $\sin 60° = \cos 30°$

5. A box sits on a spring in an elevator at rest with the spring at an equilibrium length L. Which of the following scenario(s) would result in the spring being compressed to a smaller length than L?



   (a) Elevator is going upward and coming to a stop
   (b) Elevator is going upward at a constant speed
   (c) Elevator is starting to go upward from rest Correct
   (d) Elevator is going downward at constant speed
   (e) More than one of the above.

6. A box of mass M is sliding on the floor with a kinetic friction coefficient of $\mu_k = \mu$ with initial velocity $v_0 = v$ and it comes to a stop in distance D. Another box slides on the floor but it has mass $2M$. Which parameters would allow it to stop in the same distance D?



   (a) $v_0 = 2v, \mu_k = \mu$
   (b) $v_0 = v, \mu_k = 2\mu$
   (c) $v_0 = v/2, \mu_k = \mu$
   (d) $v_0 = v, \mu_k = \mu/2$
   (e) None of the above. Correct

   Nothing has to change because the mass cancels out. Work done by friction = initial KE. $\mu_k MGD = \frac{1}{2}Mv^2$

7. Two boys, Al and Bob, are on the balcony of an apartment and each throws an object at the same time. The objects land on the flat parking lot below with the same speed. Al throws his object upward at 30 degrees to the horizontal and Bob throws his object downward at an angle of 30 degrees to the horizontal. Ignore air resistance.

   (a) Al throws his object with initial speed that is faster than Bob's.

   (b) Al throws his object with initial speed that is slower than Bob's.

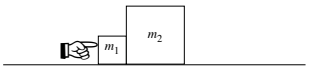
   (c) They both throw their objects at the same speed. Correct

   (d) The relative speed of the throws depends on the relative masses of the objects

   This activity is not recommended.

   Only the net change in height affects the speed on impact.

8. A finger pushes a small block of mass m_1 that is then pushing on a larger mass m_2 and both accelerate forward with the same acceleration a..



   The relationship between the *net* force on m_1, $F_{1,net}$, and the *net* force on m_2, $F_{2,net}$, is

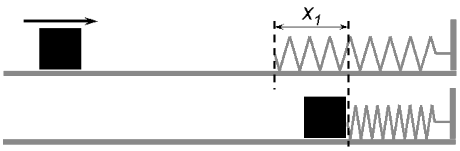
   (a) $F_{1,net} < F_{2,net}$ Correct

   (b) $F_{1,net} = F_{2,net}$

   (c) $F_{1,net} > F_{2,net}$

   The accelerations are the same so the net force on the smaller mass must be less.

9. A box hits a spring with velocity v and compresses the spring a distance x_1. If the same box hits the spring and compresses it $x_1/2$ what was its speed when hitting the spring?

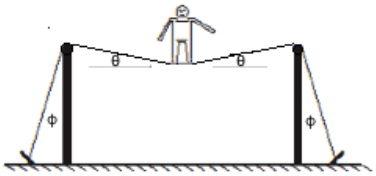


   (a) $v/2$ Correct

   (b) $v/4$

   (c) $v/\sqrt{2}$

10. A circus performer of weight W is walking along a high wire as shown and the wire deviates from horizontal by an angle θ.



    The tension in the wire F_T is

    (a) $F_T = (W/2)\sin\theta$

    (b) $F_T = (W/2)\cos\theta$

    (c) $F_T = W/(2\sin\theta)$ Correct

    (d) $F_T = W/(2\cos\theta)$

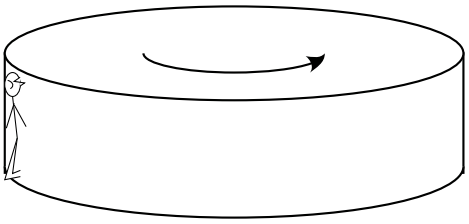
    (e) None of the above

    The weight of the performer is in equilibrium with the vertical components of the tension of the rope on the right side and left side: $mg = 2T_y$. When the angle of the rope is small, the magnitude of the tension must be large in order for the vertical component to be sufficiently large to balance the weight: $T = mg/(2\sin\theta)$.

There are four written problems. Show all your work and explain your reasoning to get full credit. No regrading possible if not written in pen. Each question is worth 10 points.

11. In a classic carnival ride, patrons stand against the wall in a cylindrically shaped room. Once the room gets spinning fast enough, the floor drops from the bottom of the room! Friction between the walls of the room and the people on the ride make them the stick to the wall so they do not slide down. In one ride, the radius of the cylindrical room is R = 8 m and the room spins with a frequency of 30 revolutions per minute. [10 marks]

    (a) Draw the free body diagram for the person "stuck" to the wall..



    (b) What is the speed of a person stuck to the wall?
    $\omega = 2\pi Rf = 6.28 \times 8m \times 0.5$ rev/s = 25.13 m/s

    (c) What is the normal force of the wall on a rider of m = 60 kg?.
    $F_N = mv^2/R = 60kg \times (25.13m/s)^2/8$ m = 4737 N

    (d) What is the minimum coefficient of friction needed between the wall and the person?
    $M_s F_N = mg\ m_s = 9.81 * R^2/v^2 = 0.124$

12. A particle is travelling along a circular path with constant speed. At time $t = -0.1$ s the velocity of the particle is $\vec{v}_1 = 15\hat{\imath} + 8\hat{\jmath}$ m/s and at time $t_2 = +0.1$ s the velocity vector is $\vec{v}_2 = 15\hat{\imath} - 8\hat{\jmath}$ m/s. [10 marks]

    (a) Find the dot product between $\vec{v}_1$ and $\vec{v}_2$: That is to say find $\vec{v}_1 \cdot \vec{v}_2$.
    225-64 = 161

    (b) Find the angle between the vectors $\vec{v}_1$ and $\vec{v}_2$.
    use dot product angle = arccos(161/289) = 56 deg = 0.98 rad

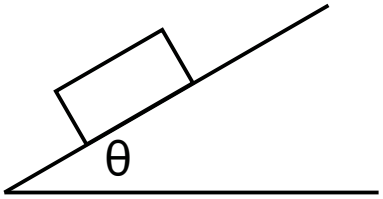
    (c) What is the average acceleration between t_1 and t_2?
    80 m/s^2

    (d) Calculate the radius of revolution assuming the particle is moving in uniform circular motion.
    $v = 2\pi R/T$
    $R = Tv/2\pi = (1.15s)(17m/s)/(6.28) = 3.11$ m

    (e) Calculate the centripetal acceleration of the circular motion.
    $2\pi v/T = 98$ m/s^2

13. A 5.76 kg box is initially traveling with a speed of 8.43 m/s as it starts up a ramp on which the kinetic friction force has a magnitude of 37.6 N. The ramp surface is tilted 30° from horizontal as shown. [10 marks]

    (a) Draw a free-body diagram of the box.



    (b) Find the velocity of the box as a function of time.
    $a = -g/2 - F_f/m = -11.42$ m/s^2
    $v(t) = v_0 + at = 8.43m/s - 11.42m/s^2)t$

    (c) At what distance from the start does the box come to a stop?

    $t_s = -v_0/a = 8.43/11.42 = 0.737s$
    $d = v_0t - \frac{1}{2}at^2 = 8.43(0.737) + \frac{1}{2}(-11.42m/s^2)(0.737^2) = 3.11$ m

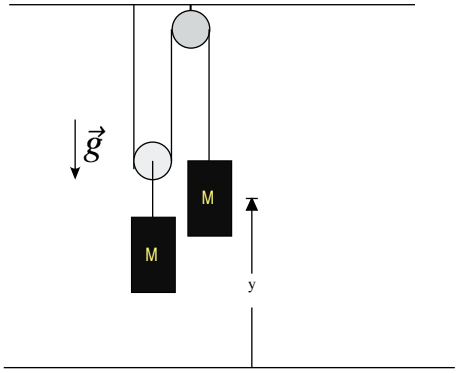
    (d) What is the work done by friction on the box from start to stop?
    $W = F_fd = (3.11m)(37.6N) = 116.9$ J

    (e) What is the power dissipated by the friction force on the box as it is sliding up the ramp?

    $P = F_fv = (37.6N)(8.43m/s - 11.42m/s^2)t = 316.98W - (429.4W/s)t$

14. Two equal masses, M, are hung from a rope that passes through two pulleys as shown. One mass hangs from a pulley in the middle of the rope and the other from the end of the rope. The other end of the rope is attached to the ceiling. [10 marks]

(a) Express the gravitational potential energy of the system in terms of the height of the end mass above the ground, y, the mass, M, and g..

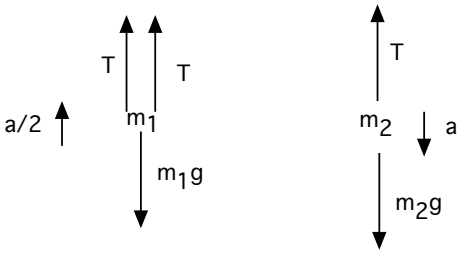


Let H be the height of the left mass when the right mass is on the ground at $y = 0$.

$U(y) = Mgy + Mg(H - y/2) = Mg(H - y/2)$

Any constant may be added to the potential and it is still valid. e.g., $U' = Mgy/2$ is ok too.

(b) Calculate the acceleration of the mass on the end of the rope. Express in terms of g.



$2T - mg = ma/2$

$mg - T = ma$

$2mg - 2T = 2ma$

$mg = 5ma/2$

$a = 2g/5$

If the masses are unequal, m_1 is the left=hand one and m_2 the right-hand one on the end of the rope:

$$a = 2g\frac{2m_2 - m_1}{m_1 + 4m_2}$$

If m_1 = 0.100 kg and $m_2 = 0.130$ kg then $a = 2.641$ m/s^2.

(c) Calculate the tension in the rope in terms of M and g.

$$T = mg - ma = 3mg/5$$

or for unequal masses

$$T = \frac{3gm_1m_2}{m_1 + 4m_2}$$