December 13, 2008
(9:00 am – 12:00 pm)

FINAL EXAMINATION

PAPER NO.: 484

PAGE NO.: 1 of 5 (+ formula sheet)

COURSE NO.: PHYS 1050

TIME: 3 hours

EXAMINATION: Physics 1: Mechanics

EXAMINERS: K. S. Sharma, G. Williams, C-M Hu

All questions are of equal value. Answer all questions. No marks are subtracted for wrong answers.

Record all answers on the computer score sheet provided. **USE PENCIL ONLY!** Black pen will look good but may not be read reliably by the scoring machine. **Mark only <u>one</u> answer for each question!** Select the answer that is closest to yours.

A formula sheet is provided for your use; you may **not** use your own formula sheet or any other materials or notes. Calculators of any type are allowed, but not devices that store text or that can communicate with other such devices.

Be sure your name and student number are printed on the score sheet and the student number correctly coded in the box at the top right-hand side of the sheet.

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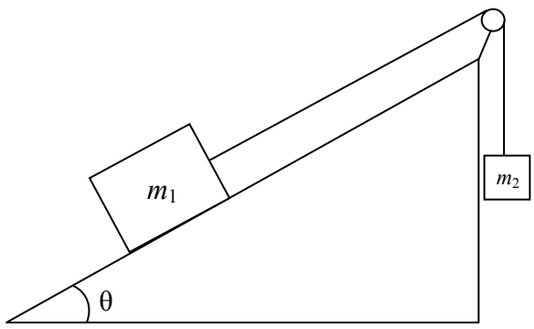
1. A particle of mass m = 0.3 kg is acted upon by a force so that its position vector, $\vec{r}(t) = 2.0t^2\hat{i} - 5.0t^2\hat{j} + t^2\hat{k}$ where t is in s. What is the (instantaneous) power delivered by this force to the particle at time t = 2.0s?

   (a) 62 watts (b) 72 watts (c) 81 watts (d) 41 watts (e) 70 watts

2. A particle of mass m = 0.10 kg moves so that its position vector, $\vec{r}(t) = 0.50t^3\hat{i} - 3.0\hat{j} + (0.50t^2 - t)\hat{k}$ where t is in s. What is the magnitude of the angular momentum of this particle about the origin at time t = 1.0s?

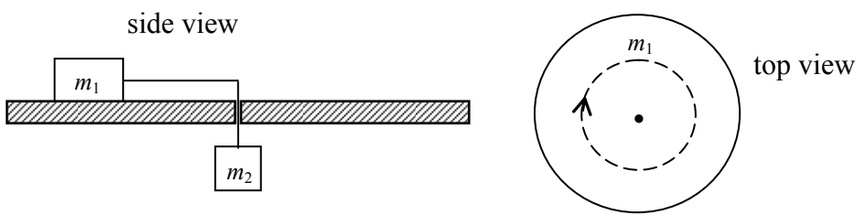
   (a) 1.4 kg m^2/s
   (b) 0.91 kg m^2/s
   (c) 0.43 kg m^2/s
   (d) 1.0 kg m^2/s
   (e) 0.46 kg m^2/s

3. A mass m_1 = 10 kg, sits on a plane inclined at angle θ = 30.0º to the horizontal. The coefficient of static friction for the inclined plane is μ_s = 0.40, while the coefficient of kinetic friction is μ_k = 0.30. The mass m_1 is attached by a massless string passing over a frictionless pulley to a second mass m_2 = 1.4 kg which hangs freely. The magnitude of the acceleration of this system is:



   (a) 0 m/s^2 (b) 0.10 m/s^2 (c) 0.86 m/s^2 (d) 1.2 m/s^2 (e) 1.4 m/s^2

4. A mass $m_1 = 6.0$ kg sits on a frictionless table, and rotates at a constant speed $v = 3.0$ m/s in a circle of radius R = 1.5 m. m_1 is attached by a massless string which passes through a hole in the centre of the table to a second m_2 (which hangs freely without moving). There is no friction present at the point where the string passes through the hole in the table. The mass m_2 is:



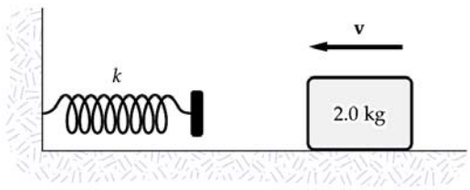
(a) 1.2 kg (b) 5.2 kg (c) 5.5 kg (d) 2.8 kg (e) 3.7 kg

5. A stunt pilot of mass 110 kg flies her plane in a vertical circle of radius R = 100.0 m. If she flies without fastening her seat belt, what is the minimum speed that the plane must maintain at the top of this vertical circle if the pilot is not to fall out. (The pilot's head is always directed towards the centre of the vertical circle).

(a) 6.5 m/s (b) 9.8 m/s (c) 12 m/s (d) 31 m/s (e) 36 m/s

6. The horizontal surface on which the block slides is frictionless. The speed of the block before it touches the spring is 6.0 m/s. How fast is the block moving at the instant the spring has been compressed 0.15 m if the spring constant has a value of $k = 2.0$ kN/m?

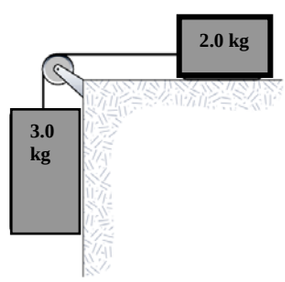
(a) 3.7 m/s
(b) 4.4 m/s
(c) 4.9 m/s
(d) 5.4 m/s
(e) 14 m/s



7. A 10 kg block on a rough horizontal surface is attached to a light spring (force constant = 1.4 kN/m). The block is pulled 0.080 m to the right from its equilibrium position and released from rest. The frictional force between the block and surface has a magnitude of 30.0 N. What is the kinetic energy of the block as it passes through its equilibrium position?

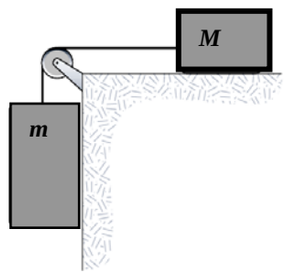
(a) 4.5 J (b) 2.1 J (c) 6.9 J (d) 6.6 J (e) 4.9 J

8. The two masses in the figure are attached by a massless string passing over a frictionless pulley with zero rotational inertia. The system is released from rest. After the 3.0 kg mass has fallen 1.5 m, it is moving with a speed of 3.8 m/s. How much work is done during this time interval by the frictional force acting on the 2.0 kg mass?



(a) –12 J (b) –17 J (c) –20 J (d) –8.0 J (e) –28 J

9. A mass m = 4.0 kg is connected, as shown, by a massless cord to a mass M = 6.0 kg, which slides on a frictionless horizontal surface. The pulley rotates about a frictionless axle and has a radius R = 0.12 m and a moment of inertia I = 0.090 kg · m^2. The cord does not slip on the pulley. What is the magnitude of the acceleration of m?



(a) 2.4 m/s^2
(b) 2.8 m/s^2
(c) 3.2 m/s^2
(d) 4.2 m/s^2
(e) 1.7 m/s^2

10. At an instant when a particle of mass 80.0 grams has a velocity of 25 m/s in the positive *y* direction, a 75.0 grams particle has a velocity of 20.0 m/s in the positive *x* direction. What is the speed of the center of mass of this two-particle system at this instant?

(a) 16 m/s (b) 45 m/s (c) 23 m/s (d) 20 m/s (e) 36 m/s

11. Three particles are placed in the *xy* plane. A 40.0 kg particle is located at (3.0, 4.0) m, and a 50.0 kg particle is positioned at (–2.0, –6.0) m. Where must a 20.0 kg particle be placed so that the center of mass of this three-particle system is located at the origin?

(a) (–1.0, –3.0) m
(b) (–1.0, 2.0) m
(c) (–1.0, 12) m
(d) (–1.0, 7.0) m
(e) (–1.0, 3.0) m

12. A 4.0 kg particle is moving horizontally with a speed of 5.0 m/s when it strikes a vertical wall. The particle rebounds horizontally with a speed of 3.0 m/s. What is the magnitude of the impulse delivered to the particle?

(a) 24 N s
(b) 32 N s
(c) 40 N s
(d) 30 N s
(e) 8.0 N s

13. A 3.0 kg mass sliding on a frictionless surface has a velocity of 5.0 m/s east when it undergoes a one-dimensional inelastic collision with a 2.0 kg mass that has an initial velocity of 2.0 m/s west. After the collision the 3.0 kg mass has a velocity of 1.0 m/s east. How much kinetic energy does the two-mass system lose during the collision?

(a) 22 J (b) 28 J (c) 26 J (d) 20 J (e) 24 J

14. A wheel rotates with a constant angular acceleration of π rad/s^2. During a certain time interval its angular displacement is π rad. At the end of the interval its angular velocity is 2π rad/s. Its angular velocity at the beginning of the interval is:

(a) zero
(b) 1 rad/s
(c) $\pi\sqrt{2}$ rad/s
(d) π rad/s
(e) 2π rad/s

15. A block is attached to each end of a massless rope that passes over a pulley suspended from the ceiling. The pulley has a non-zero mass and therefore a non-zero rotational inertia. The blocks do not have the same mass. If the rope does not slip on the pulley, then at any instant after the blocks start moving the rope:

(a) pulls on both blocks, but exerts a greater force on the heavier block
(b) pulls on both blocks, but exerts a greater force on the lighter block
(c) pulls on both blocks and exerts the same non-zero force on both
(d) does not pull on either block
(e) pulls only on the lighter block

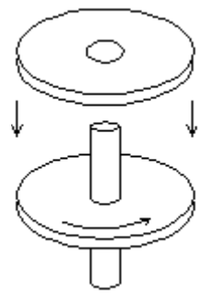
16. A disk has a rotational inertia of 6.0 kg · m^2 and a constant angular acceleration of 2.0 rad/s^2. If it starts from rest the work done during the first 5.0 s by the net torque acting on it is:

(a) 0.00 J (b) 30.0 J (c) 300 J (d) 60.0 J (e) 600 J

17. A wheel starts from rest and spins with a constant angular acceleration. As time goes on the acceleration vector for a point on the rim:

(a) decreases in magnitude and becomes more nearly tangent to the rim
(b) decreases in magnitude and becomes more nearly radial
(c) increases in magnitude and becomes more nearly tangent to the rim
(d) increases in magnitude and becomes more nearly radial
(e) increases in magnitude but retains the same angle with the tangent to the rim

18. A wheel , with rotational inertia *I*, mounted on a vertical shaft with negligible rotational inertia, is rotating with angular speed ω_0. A nonrotation wheel with rotational inertial 2*I* is suddenly dropped onto the same shaft as shown. The resultant combination of the two wheels and shaft will rotate at:



(a) $\omega_0/2$ (b) $2\omega_0$ (c) $\omega_0/3$ (d) $3\omega_0$ e) $\omega_0/4$

19. A playground merry-go-round has a radius *R* and a rotational inertia *I*. When the merry-go-round is at rest, a child with mass *m* runs with speed *v* along a line tangent to the rim and jumps onto the merry-go-round. The angular velocity of the merry-go-round is then:

(a) mv/I
(b) v/R
(c) mRv/I
(d) $2mRv/I$
(e) $mRv/(mR^2+I)$

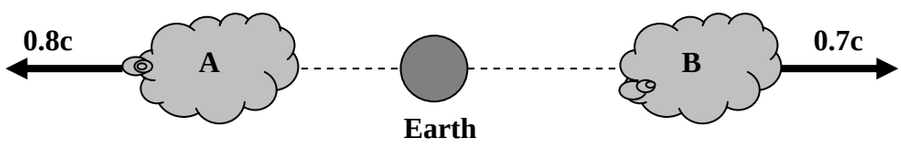
20. A pulley with radius R and rotational inertia I is free to rotate on a horizontal fixed axis through its center. A massless string passes over the pulley. A block of mass m_1 is attached to one end and a block of mass m_2 is attached to the other. At one time the block with mass m_1 is moving downward with speed v. If the string does not slip on the pulley, the magnitude of the total angular momentum, about the pulley centre, of the blocks and pulley, considered as a system, is given by:

(a) $(m_1 - m_2)\mathrm{v}R - I\mathrm{v}/R$
(b) $(m_1 - m_2)\mathrm{v}R + I\mathrm{v}/R$
(c) $(m_1 + m_2)\mathrm{v}R - I\mathrm{v}/R$
(d) $(m_1 + m_2)\mathrm{v}R + I\mathrm{v}/R$
(e) none of the above

21. A 2.0 kg object moving along the x-axis at 3.0 m/s strikes a 1.0 kg object initially at rest. Immediately after the collision, the 2.0 kg object has a velocity of 1.5 m/s directed 30° from its initial direction of motion. What is the x-component of the velocity of the 1.0 kg object just after the collision?

(a) 3.7 m/s (b) 3.4 m/s (c) 1.5 m/s (d) 2.4 m/s (e) 4.1 m/s

22. Two galaxies are observed to be moving away from the earth along the same line. Galaxy A is moving away with a velocity of 0.8c and galaxy B is on the other side of the earth from galaxy A and is moving away from the earth with a velocity of 0.7c. What is the speed of galaxy B relative to galaxy A?



(a) 1.5c (b) 0.10c (c) 1.0c (d) 0.50c (e) 0.96c

During a soccer game, Superman kicks a soccer ball from one end of a soccer field to the other. According to an observer sitting at the side of the field, the ball travels at a speed of 0.500 c during its flight and the soccer field has a length of 100.0 m:

23. How long is the field as seen by an observer at rest with respect to the ball?

(a) 115 m (b) 86.6 m (c) 100 m (d) 75.0 m (e) 750 m

24. How much time does the ball take to cross the field as seen by an observer sitting at the side of the field?

(a) 667 ns (b) 770 ns (c) 889 ns (d) 577 ns (e) 500 ns

25. How much time does the ball take to cross the field as measured by an observer at rest with respect to the ball?

(a) 667 ns (b) 770 ns (c) 889 ns (d) 577 ns (e) 500 ns