King Fahd University of Petroleum and Minerals

Department of Physics

PHYS101-051

FINAL EXAM

Test Code: **100**

Tuesday, 24 January 2006 in Building 54

Exam Duration: 3 hrs (from 12:30pm to 3:30pm)

Name:	
Student Number:	
Section Number:	

1. A car starts from point A, goes 100 km in a straight line to point B, immediately turns around, and returns to point A. The time for this round trip is 2 hrs. The magnitude of the average velocity of the car for this round trip is:
   A) 80 km/hr
   B) 50 km/hr
   C) 100 km/hr
   D) 200 km/hr
   E) 0

2. Two vectors $\vec{B}$, and $\vec{C}$ are such that: $\vec{C} = \vec{B} - 2\vec{A}$ and $\vec{B} = 6\hat{j}$ where $\vec{A} = 4\hat{i}$. Find the angle between vectors $\vec{C}$ and $\vec{B}$.
   A) 53°
   B) 37°
   C) 30°
   D) 60°
   E) 45°

3. In the projectile motion (see Fig. 1) for what angle θ does H=R? $\left(R = \dfrac{2v_o^2 \sin\theta \cos\theta}{g} \right)$

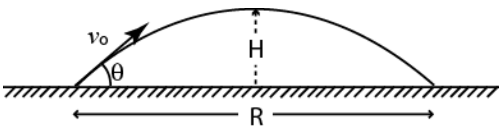

Figure 1

   A) 62°
   B) 94°
   C) 37°
   D) 76°
   E) 45°

4. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:
   A) both tangent to the circular path
   B) both perpendicular to the circular path
   C) perpendicular to each other
   D) opposite to each other
   E) none of the other answers

5. You stand on a spring scale on the floor of an elevator. The scale shows the highest reading when the elevator:
   A) moves downward at constant speed
   B) moves upward with decreasing speed
   C) remains at rest
   D) moves downward with increasing speed
   E) moves upward with increasing speed

6. A massless rope passes over a massless pulley suspended from the ceiling. A 4-kg block is attached to one end and a 5-kg block is attached to the other end. If the acceleration due to gravity is g, the magnitude of the acceleration of the 5-kg block is:
   A) $g/4$
   B) $5g/9$
   C) $4g/9$
   D) $g/5$
   E) $g/9$

7. A crate is sliding down an incline that is 35° above the horizontal. If the coefficient of kinetic friction is 0.40, the acceleration of the crate is:
   A) 0
   B) 2.4 m/s^2
   C) 5.8 m/s^2
   D) 8.8 m/s^2
   E) 10.3 m/s^2

8. A boat is sailing at 12 km/h 30° W of N with respect to a river that is flowing at 6.0 km/h East relative to the ground. As observed from the ground, the boat is sailing:
   A) 30° East of North
   B) due North
   C) 30° West of North
   D) 45° East of North
   E) none of the other answers

9. A block initially at rest is allowed to slide down a frictionless ramp of height h and attains a speed v at the bottom. To achieve a speed $2v$ at the bottom, how high must the new ramp be?
   A) h
   B) $2h$
   C) $3h$
   D) $5h$
   E) $4h$

10. A crane lifts a 4080 kg shipping container through a vertical height of 2.0 m in 8.0 s. What is the average power that the crane motor must supply? (Assume the crane to be moving with constant velocity and ignore friction).
    A) 20 kW
    B) 30 kW
    C) 40 kW
    D) 10 kW
    E) 50 kW

11. A 0.50-kg block slides along a horizontal frictionless surface at 2.0 m/s. It is brought to rest by compressing a spring of spring constant 800 N/m. The maximum spring compression is:
    A) 0
    B) 3.0 cm
    C) 5.0 cm
    D) 80 cm
    E) 10 cm

12. A rectangular block is moving along a horizontal frictionless path when it encounters a loop the loop as shown in Fig. 2. The block passes points P, Q, R, S before returning to the horizontal track again and passing through point T. At point R:

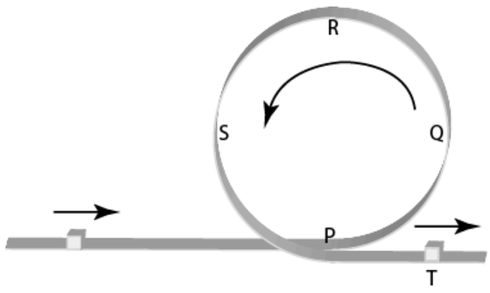

Figure 2

A) its mechanical energy is a minimum
B) the forces on it are balanced
C) it is not accelerating
D) its speed is a minimum
E) it experiences a net upward force

13. In a head-on elastic collision of a projectile with a stationary target, the final kinetic energy of the projectile is minimum if:
A) the projectile is initially traveling very fast
B) the projectile is traveling very slowly
C) the projectile is much more massive than the target particle
D) the projectile is much less massive than the target particle
E) the projectile and target have the same mass

14. A disk starts from rest and rotates about a fixed axis, subject to a constant net torque. The work done by the torque during the time from t=0 to 5 s is W_1 and during the time from t=5 to 10 s is W_2. W_2/W_1 is equal to:
A) 1
B) 2
C) 1/2
D) 3
E) 1/4

15. A particle, held by a string whose other end is attached to a fixed point O, moves in a circle on a horizontal frictionless surface. If the string is cut, the angular momentum of the particle about the point O:
A) increases
B) decreases
C) does not change
D) changes direction but not magnitude
E) none of these

16. A cube of volume 8.0 cm^3 is made of material with a bulk modulus of 3.5×10^9 N/m^2. When it is subjected to a pressure of 3.0×10^5 Pa, the change in its volume ($|\Delta V|$) is:
A) 3.1×10^{-4} cm^3
B) 4.5×10^{-4} cm^3
C) 9.9×10^{-4} cm^3
D) 6.9×10^{-4} cm^3
E) 1.8×10^{-4} cm^3

17. A uniform rigid rod having a mass of 50 kg and a length of 2.0 m rests on two supports *A* and *B* as shown in the Fig. 3. When a block of mass 60 kg is kept at point *C* at a distance of *x* from the center, the rod is about to be lifted off *A* (the normal force on the rod at *A* is zero). The value of *x* is:

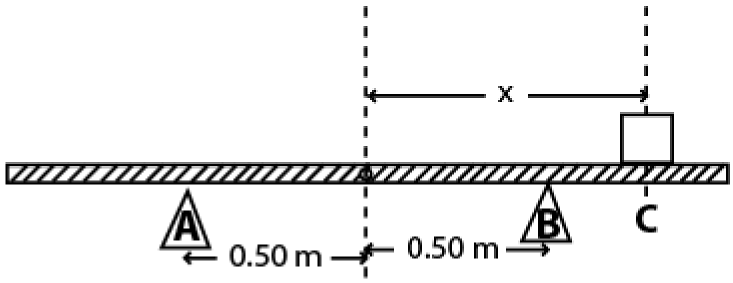

Figure 3

A) 0.92 m
B) 1.2 m
C) 0.55 m
D) 1.7 m
E) 0.44 m

18. A uniform beam having a mass of 60 kg and a length of 2.8 m is held in place at its lower end by a pin (P). Its upper end leans against a vertical frictionless wall as shown in the Fig. 4. The force on the rod from the wall is:

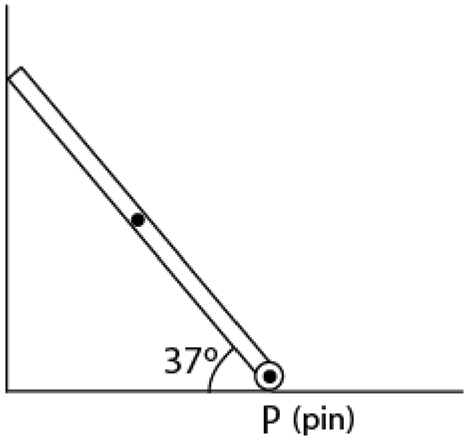

Figure 4

A) 100 N
B) 390 N
C) 550 N
D) 780 N
E) 980 N

19. Calculate the magnitude and direction of net gravitational force on particle of mass *m* due to two particles each of mass *M*, where *m* =1000 kg and *M* =10000 kg and are arranged as shown in the Fig. 5.

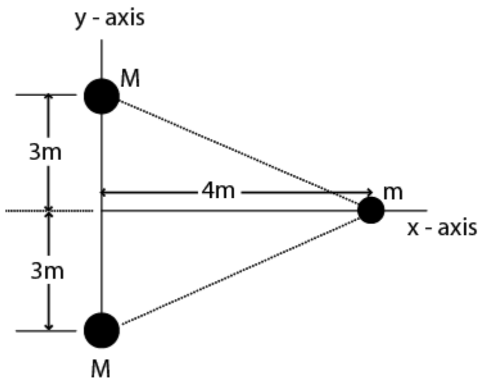

Figure 5

A) 4.3×10^{-5} N directed along positive x-axis
B) 4.3×10^{-5} N directed along negative x-axis
C) 2.2×10^{-5} N directed along positive x-axis
D) 2.2×10^{-5} N directed along negative x-axis
E) 8.3×10^{-5} N directed along positive x-axis

20. One of the moons of planet Mars completes one revolution around Mars in 1.26 Earth days. If the distance between Mars and the moon is 23460 km, calculate the mass of Mars.
A) 3.22×10^{23} kg
B) 7.45×10^{23} kg
C) 6.45×10^{23} kg
D) 5.34×10^{23} kg
E) 1.45×10^{23} kg

21. A satellite is moving in a circular orbit around a planet. If the kinetic energy of the satellite in its orbit is 1.87×10^{9} J, what is the mechanical energy of the orbiting satellite?
A) 1.87×10^{9} J
B) 3.74×10^{9} J
C) $- 3.74 \times 10^{9}$ J
D) $- 1.87 \times 10^{9}$ J
E) $- 0.93 \times 10^{9}$ J

22. A projectile was fired straight upward from Earth's surface with an initial speed v_i such that it reaches a maximum height of $2R_E$ above the Earth surface (Mass of the Earth = 5.96×10^{24} kg and radius of the Earth, $R_E = 6.37 \times 10^{6}$ m). The initial speed v_i is:
A) 9.12 km/s
B) 11.2 km/s
C) 3.72 km/s
D) 2.85 km/s
E) 4.43 km/s

23. Several cans of different sizes and shapes are all filled with the same liquid to the same height *h* (See Fig. 6). Then:

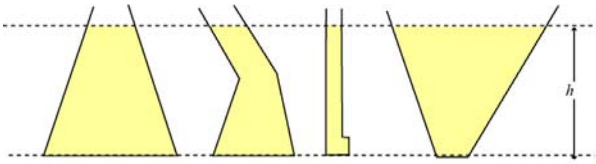

Figure 6

A) the weight of the liquid is the same for all cans
B) the force of the liquid on the bottom of each can is the same
C) the least pressure is at the bottom of the can with the largest bottom area
D) the greatest pressure is at the bottom of the can with the largest bottom area
E) the pressure on the bottom of each can is the same

24. Fig. 7 shows a U-tube with cross-sectional area *A* and partially filled with oil of density ρ. A solid cylinder, which fits the tube tightly but can slide without friction, is placed in the right arm. The system is in equilibrium. The weight of the cylinder is:

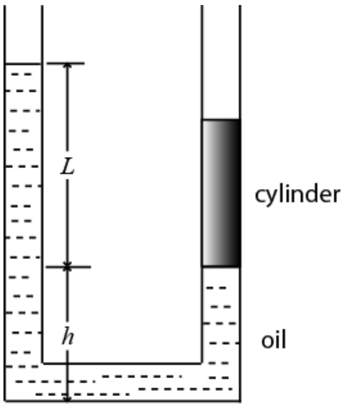

Figure 7

A) $AL\rho g$
B) $L^3\rho g$
C) $A\rho(L + h)g$
D) $A\rho(L - h)g$
E) none of the others

25. An object hangs from a spring balance. The balance indicates 30 N in air and 20 N when the object is submerged in water. What does the balance indicate when the object is submersed in a liquid with a density that is half that of water?
A) 20 N
B) 25 N
C) 30 N
D) 35 N
E) 40 N

26. An incompressible liquid flows along the pipe as shown in Fig. 8 with $A_1=2A_2$. The ratio of the mass flow rate R_2/R_1 is:

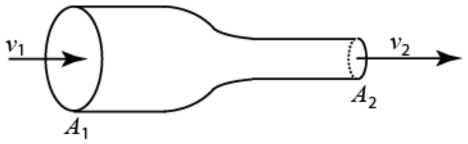

Figure 8

A) 1
B) 2
C) 1/2
D) 4
E) 1/4

27. In simple harmonic motion, the magnitude of the acceleration is greatest when:
A) the displacement is zero
B) the displacement is maximum
C) the speed is maximum
D) the force is zero
E) the speed is between zero and its maximum

28. A particle is in simple harmonic motion along the x axis. The amplitude of the motion is x_m. At one point in its motion its kinetic energy is $K = 5$ J and its potential energy (measured with $U = 0$ at x = 0) is $U = 3$ J. When it is at $x = x_m$, the kinetic and potential energies are:
A) $K = 5$ J and $U = 3$J
B) $K = 5$ J and $U = –3$J
C) $K = 8$ J and $U = 0$
D) $K = 0$ and $U = 8$J
E) $K = 0$ and $U = –8$J

29. A 0.25-kg block oscillates at the end of the spring with a spring constant of 200 N/m. If the system has a mechanical energy of 6.0 J, then the amplitude of the oscillation is:
A) 0.06m
B) 0.17m
C) 0.24m
D) 4.9m
E) 6.9m

30. A simple pendulum has length L and period T. As it passes through its equilibrium position, the string is suddenly clamped (fixed) at its midpoint (See Fig. 9). The period then becomes:

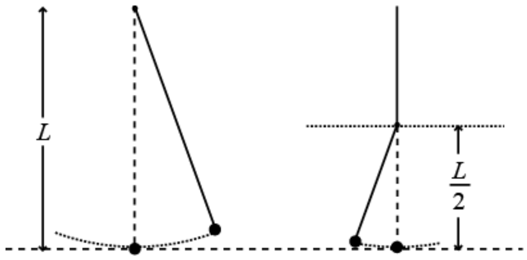

Figure 9

A) $\frac{T}{\sqrt{2}}$
B) 2 T
C) $T/2$
D) $4T$
E) $T/4$

PHYS-101 Formula Sheet for the Final Exam

$\vec{v} = \vec{v}_o + \vec{a}t$

$\vec{r} - \vec{r}_o = \vec{v}_o t + \frac{1}{2}\vec{a}t^2$

$v^2 = v_o^{\ 2} + 2\vec{a}\cdot(\vec{r} - \vec{r}_o)$

$\vec{r} - \vec{r}_o = \frac{1}{2}(\vec{v} + \vec{v}_o)t$

$a_r = \dfrac{v^2}{r} \quad a_t = \dfrac{d|\vec{v}|}{dt} \quad H = \dfrac{v_o^2 \sin^2\theta}{2g}$

$\vec{a} = \vec{a}_t + \vec{a}_r$

$\vec{F}_{net} = m\vec{a} = \dfrac{d\vec{p}}{dt}$

$f_k = \mu_k N$

$f_s \le \mu_s N$

$W = \int \vec{F}\cdot d\vec{s}$

If $\vec{F}$ is a constant $\quad W = \vec{F}\cdot\vec{s}$, $P = \vec{F}.\vec{v}$

$W_{net} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$W_c = -\Delta U$

$\Delta U_s = \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2, F_s = -kx$

$\Delta U_g = mg(y_f - y_i)$

$W = \Delta K + \Delta U + \Delta E_{th}; \qquad \Delta E_{th} = f_k d$

$\vec{p} = m\vec{v}$

$\vec{J} = \Delta\vec{p} = \int \vec{F}dt = \vec{F}_{avg}\Delta t$

$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$

$\vec{R}_{cm} = \dfrac{\sum m_i\vec{r}_i}{\sum m_i} = \dfrac{1}{M}\int \vec{r}\,dm$

$\vec{v}_{cm} = \dfrac{\sum m_i\vec{v}_i}{\sum m_i}; \quad \vec{p}_{cm} = \sum m_i\vec{v}_i$

$\omega = \dfrac{d\theta}{dt}; \quad \alpha = \dfrac{d\omega}{dt}$

$s = r\theta, \ v = r\omega$

$a_t = r\alpha; \ a_r = r\omega^2$

If α is a constant :

$\omega = \omega_o + \alpha t$

$\theta - \theta_o = \omega_o t + \frac{1}{2}\alpha t^2$

$\theta - \theta_0 = \dfrac{\omega + \omega_0}{2}t$

$\omega^2 = \omega_o^2 + 2\alpha(\theta - \theta_o)$

$I = \sum m_i r_i^2 = \int r^2\,dm$

$I_p = I_{com} + Md^2$

$\vec{\tau} = \vec{r}\times\vec{F} \qquad |\vec{A}\times\vec{B}| = AB\sin\theta$

$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$, $\vec{A}\cdot\vec{B} = AB\cos\theta$

$P = \dfrac{dW}{dt} = \tau\omega$

For a solid rotating about a fixed axis :

$K_{rot} = \frac{1}{2}I\omega^2; \quad L_z = I\,\omega$

$W = \int \tau\,d\theta$

$\vec{L} = \vec{r}\times\vec{p} = m(\vec{r}\times\vec{v})$

$\vec{\tau} = \dfrac{d\vec{L}}{dt}$

$\sum \tau_{ext} = \dfrac{dL}{dt} = I\alpha$

For static equilibrium

$\sum \vec{F} = 0, \quad \sum \vec{\tau} = 0$

$E = \dfrac{F/A}{\Delta L/L_o}; \ \mathrm{G} = \dfrac{F/A}{\Delta x/h}; \ \mathrm{B} = \dfrac{p}{|\Delta V|/V}$

$x = x_m \cos(\omega t + \phi)$

$k = m\omega^2; \quad T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{m}{k}}$

$E = \frac{1}{2}kx_m^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

$T = 2\pi\sqrt{\dfrac{L}{g}}; \quad T = \dfrac{1}{f}$

$F_g = \dfrac{Gm_1m_2}{r^2}; \quad U = -\dfrac{Gm_1m_2}{r}$

$E = \frac{1}{2}mv^2 - \dfrac{GMm}{r} = -\dfrac{GMm}{2r}$

$v_{esc} = \sqrt{\dfrac{2GM}{R}}; \quad T^2 = \left(\dfrac{4\pi^2}{GM}\right)r^3$

$P = \dfrac{F}{A}; \quad \rho = \dfrac{m}{V}$

$P = P_o + \rho gh$

$F_b = m_f g = \rho_f V_f g$

$A_1v_1 = A_2v_2 = \text{constant}$

$P + \frac{1}{2}\rho v^2 + \rho gy = \text{constant}$

$G = 6.67\times10^{-11}\,Nm^2/kg^2$

$P_{atm} = 1.013\times10^5\,Pa = 1\,atm$

$I_{com}(cylinder) = \frac{1}{2}MR^2 = I_{com}(disk)$

$I_{com}(thin\ rod) = \frac{1}{12}ML^2$

$I_{com}(sphere) = \frac{2}{5}MR^2; \quad I_{com}(thin\ hoop) = MR^2$

$\rho_{water} = 1\,g/cm^3; \quad g = 9.80\,m/s^2$

Answer Key

1. E
2. A
3. D
4. C
5. E
6. E
7. B
8. B
9. E
10. D
11. C
12. D
13. E
14. D
15. C
16. D
17. A
18. B
19. B
20. C
21. D
22. A
23. E
24. A
25. B
26. A
27. B
28. D
29. C
30. A